THE RESOURCES OF THE EMPIRE

A business man's survey of the Empire's resources prepared by the Federation of British Industries.

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THE RESOURCES OF THE EMPIRE SERIES

OILS, FATS, WAXES, AND RESINS

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With a Special Section on Mineral Lubricating Oils by HAROLD MOORE

(Consulting Chemist and Petroleum Technologist)

WITH A FOREWORD BY

H.R.H. THE PRINCE OF WALES, K.G.

AND GENERAL INTRODUCTIONS BY

THE RT. HON. SIR ERIC GEDDES, G.C.B.

AND

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FOREWORD

BY

H.R.H. THE PRINCE OF WALES, K.G.

No business man—especially should he contemplate an extension of activities—can afford to dispense with periodical stock-taking. The necessity for this applies equally to a country or empire, particularly when recovering from a devastating war that has resulted in heavy liabilities and dislocated the accustomed routine of trade and commerce. We are all proud of the British Empire, embracing more than a quarter of the world's land area and a similar proportion of its inhabitants, but very many of us fail to realize the infinite variety and vast extent of the Empire's natural products, which are capable of being made self-sufficing.

The volumes of this Series pass in review the material resources of the Empire, and constitute, as it were, an Imperial stock-taking. They deal with food and raw materials of every kind, summarize the present condition of inter-Imperial trade, and indicate where further developments are possible.

At the present moment, when our great British Empire Exhibition is imminent, they should be of special interest both at home and overseas. It gives me great pleasure to recommend them to all those who have at heart the proper organization of the Empire's natural wealth.

Edward P.

GENERAL INTRODUCTION

BY

THE RIGHT HON. SIR ERIC GEDDES, G.C.B.

In undertaking the preparation of this Series the Federation of British Industries has, I am convinced, rendered a really practical service to business men throughout the Empire.

Hitherto, there has been no standard work of reference giving the information which ought to be in the possession of business men all over the world regarding the resources of Great Britain and the other countries of the Empire in the materials of industry.

It is true that there are some excellent monographs describing in general terms the resources of isolated parts of the Empire, and a very few dealing comprehensively with individual products, but, apart altogether from the fact that the sum total of the information contained in existing publications falls hopelessly far short of what is requisite, such information as exists is hardly prepared in a form adapted to the requirements of the practical man who wants neither a bare table of statistics about the products essential to him in his business nor a mere general description of the extent of the resources of a given country in those products. On the contrary, the business man wants information not only as to the available supplies of his raw materials, but as to the quality of the supplies produced in different parts of the world, as to the amount of the undeveloped resources, as to the transport facilities, as to the local conditions of labour, etc., and as to the chances of present supplies available for import in this country being absorbed in the near future by local demands. In other words, he wants particulars of all those factors which have to be taken into account in the ordinary course of business, and he wants those particulars arranged in an accessible form.

The aim of this Series has been to give this information in this form, and thus to provide not only for our own use, but for the use of traders all over the world, a compendious Buyers' Guide to our Imperial resources. I venture to think that the present is a very appropriate time for this undertaking. It is not only that all our thoughts are being turned towards the idea of Empire trade and Empire development by the great Exhibition which is shortly to be opened, and which will be the most impressive demonstration of our Imperial productiveness that the world has yet seen. The whole trend of economic circumstances is forcing us in the same direction.

The world war has disastrously affected the Continent of Europe as a market for the manufactured goods of Great Britain and the products of the British Dominions. Even foreign countries which were neutral in the great struggle have suffered in the same way, though in a less degree. Our trade

with the Far East and South America has suffered serious diminution, and though more than five years have now elapsed since the cessation of hostilities the resumption of normal conditions seems but little nearer. Moreover, foreign tariffs are rising higher and higher against us all over the world. Meanwhile our own productive capacity has been substantially increased and our population has grown to such an extent that we have now two million more mouths to feed and a million more men to employ than we had in 1914. It seems clear, therefore, that we need some reorientation of our commercial policy, and the obvious direction for this seems to be the cultivation of our own inheritance. A study of the facts shows that there is good hope in such a policy. Britons in all parts of the world are bound together by ties of sentiment and custom which neither distance nor difference of conditions can seriously weaken. Not only has the tremendous investment of British money in our Overseas Dominions bound us with a golden chain: there are a thousand invisible impulses always strengthening the bond. Even in 1913 our trade with the Empire was about 25 per cent. (imports) and 36 per cent. (exports) of our total world trade. The following tables show this in more detail with a comparison with the figures for the latest twelve months available. From these it will be seen that our imports from Imperial sources show a substantial advance over pre-war, the export figures remaining about the same.

PERCENTAGES OF IMPORTS FROM VARIOUS SOURCES.

Consigned from—	*October, 1922 to September, 1923.*	*Year* 1913.
British India	6·0	6·3
Self-governing Dominions	16·3	13·3
Other British countries (except Hong Kong)	5·3	5·3
Europe	33·2	40·4
United States	19·6	18·4
South and Central America	10·8	10·0
Other countries	8·8	6·3

PERCENTAGES OF EXPORTS (U.K. GOODS) TO VARIOUS DESTINATIONS.

Consigned to—	*October, 1922, to September, 1923.*	*Year* 1913.
British India	12·2	13·4
Self-governing Dominions	18·0	17·5
Other British countries (except Hong Kong)	5·7	5·4
Europe	34·2	34·4
United States	8·0	5·6
South and Central America	8·8	10·6
Other countries	13·1	13·1

The following table shows the areas and populations of the British territories on the various continents:

SUMMARY OF AREA AND POPULATION (1921-22).

	Area (Square Miles).	*Population.*
Great Britain and Ireland	121,633	47,308,000
Europe	120	234,000
Asia	2,123,418	332,772,000
Africa	3,822,667	50,119,000
America	4,009,996	11,142,000
Australasia	3,278,917	7,795,000
Total	13,356,751	449,370,000

The following table shows the approximate purchases of British goods per head of population for the first three quarters of 1923:

	£ per Head.
India, British	0·2
Federated Malay States	0·5
Australia	7·8
New Zealand	12·3
Canada	2·3
Hong Kong	7·7
Union of South Africa	2·1

The most striking features here are the huge acreage, small population, and large volume of purchase per head of Australasia, and the relatively huge populations and small volume of purchase in the Eastern territories, with Canada and South Africa occupying an intermediate position. I will recur to this contrast later.

Finally, a few figures may be given indicative of the percentage of various important world supplies either produced or available within the Empire:

	1915.	1921.
Copper (long tons)	100,000	46,000
Percentage of world production	10·2	8·5
Lead (long tons)	—	199,400
Percentage of world production	—	22·9
Tin ore (long tons)	68,300	46,800
Percentage of world production	53·9	42·2
	1913.	1923.
Wool (including alpaca, etc.) (lbs.)	5,414,067	14,077,339
Percentage of world production	74·6	77·1

It is clear, therefore, that there is an almost unlimited field for expansion of our Empire trade, whilst in many lines this possibility of a self-supporting Empire should be realizable. On the side of Great Britain the requisite productive power already exists. Overseas the position is somewhat different, and it seems clear that the requisite development of the purchasing power of the Overseas Dominions can only be produced by a gradual development of the resources of those Dominions, the surest way to which will be an increase in our own consumption of their products. There are two distinct problems, one for the tropical and one for the temperate and subtropical countries.

In the former any substantial increase in the white population is hardly to be expected, since the bulk of the work of the country must in such climates always be done by the native races. The purchasing power of these territories can therefore only be developed by the steady development of their material

resources. This, of course, means recourse to British capital, if Great Britain is to get the greatest advantage from the development and if our Imperial ideal is to be fulfilled. In our present economic condition this, of course, presents some difficulty, but if we can carry out this programme, there will follow a greater demand for British plant, machinery, shipping, rolling stock, etc., as well as a gradual increase in the consuming power of the natives.

In the temperate climates the quickest means to both our objectives lies in the speedy increase of the white populations. Nothing is more striking in the figures given above than the quantity of British goods purchased per head of these great peoples. But it is useless to attempt to stimulate emigration from this country to the Dominions unless there is a real demand for the services of the migrants when they arrive. Such a demand will only arise *pari passu* with the development of the resources of the country concerned.

The deduction to be drawn from the above considerations is obvious. How the required results are to be pursued is a more difficult question. This is not the place, nor am I the person, to embark on questions of political controversy. I will only point out that, whatever method be adopted, accurate and comprehensive knowledge of the facts is absolutely essential. (All those who are engaged in business, either here or overseas, whether it be in finance, in production, in merchanting, in transport, or in insurance, should be informed of what the different parts of our great Empire can produce, and the conditions under which production must take place and those under which the produce can be brought to market. There should be a general knowledge, too, of the amount of foreign competition with which our products and materials have to contend.)

In all my experience, whether on the railways, in the turmoil of the Great War, in Government, or in commerce, I have been continually impressed with the vital importance of accurate and comprehensive statistical knowledge—and, I am afraid, too often impressed with the difficulty of getting it.

This Series is an endeavour to supply such information regarding our Imperial resources. It cannot, unfortunately, be maintained that the results are in every case all that one could wish. However, this very inadequacy is perhaps the clearest justification for the series. The fact that complete information cannot be given shows how necessary it is that all available information should be collected and made public. Only in this way can attention be called to what is wanting and the deficiencies made good. If the Series proves as successful as I hope it may, and believe that it will, it should become a permanent institution, and it should be possible gradually to make good what is now wanting in future issues, so that eventually we may have in it a standard work of reference, which should be indispensable to all those interested or engaged in Imperial commerce or development, whether he be business man, student, or administrator.

March, 1924.

Eric Geddes

INTRODUCTORY REVIEW

BY

J. H. BATTY

THE United States is often quoted as occupying the unique position of a really self-contained country, having not only sufficient for its own requirements, but in some directions a surplus available for the needs of other nations. This applies, to some extent, to edible oils and fats. Such an advantage is of paramount importance and can scarcely be exaggerated. The country which can feed itself and produce raw materials needed for its industries is almost unshakably strong.

Our deficiency in this direction was brought keenly home to us during the War, and we are now alive to the fact that every endeavour must be made to develop the resources within the British Empire, more particularly in oil seeds, copra, and such-like products, the resultant oils of which can be used for edible purposes. The difference, of course, is that in the British Empire the natural wealth is scattered, whereas in the United States it is all within unbroken boundaries. The task of bringing this wealth to the world's markets is a problem ever fascinating to those men who take a pleasure in the Empire's development. Edible oils may be regarded as a vital necessity to practically every country. The world's consumption is steadily increasing year by year, and we are fortunate that, in this particular, the British Empire is becoming more productive and probably supplies half of the oil seeds in the world. We are shipping annually (approximately):

300,000	tons of	palm kernels	from West Africa.
130,000	,,	ground nuts	
90,000	,,	palm oil	
350,000	,,	copra	
300,000	,,	linseed	from India and the East.
350,000	,,	cotton seeds	
200,000	,,	ground nuts	
100,000	,,	sesame seed	

Also in our Colonies we produce illipé nuts, shea nuts, mowrah, and other minor oil seeds.

The great development given to the margarine trade during the last twenty years has enormously increased the consumption of oils and fats. It is estimated that the consumption of margarine in this country is between 200,000 and 250,000 tons per annum. Last year we imported about 60,000 tons, principally from Holland. In addition, the imports of butter amounted to no less than

250,000 tons in 1923. Each year brings increasing supplies of the latter from Australia and New Zealand.

The recognition of the importance of these oil seeds is no new thing in the East. Oil made from the flesh of the coconut (*Cocos nucifera*) has, from time immemorial, been produced and used by the natives of Eastern countries, both as an edible fat and as an unguent. Native-made oil being generally made from freshly gathered nuts and consumed soon after its preparation, there is no time for the development of rancidity, and in consequence the oil is palatable to the native in spite of its strong characteristic flavour. The development of free fatty acids in native-made oil and the strong coconut smell formerly prevented the oil from being used as an edible oil among Western peoples, and for many years coconut oil imported into Europe and America was used almost entirely for soap-making purposes. During the second half of last century several attempts were made to get rid of these drawbacks, and about 1880 a process for rendering oil neutral, both as to acidity and flavour, was perfected sufficiently to enable the refined oil to be sold under various trade names for edible purposes on the European and American markets. Its chief use at this stage was as a cooking fat to take the place of lard, and the harder portion of the oil (the " stearine " as it is termed) was also separated and used in the manufacture of chocolate and other confectionery. The process referred to underwent various improvements and was presently adapted for use in the case of the kindred oil from palm kernels, the product of the West African oil palm. Nowadays, edible refined oils, such as coconut and palm-kernel oils, have to satisfy much more stringent requirements than when they first appeared on the markets, and the processes of refining and deodorizing these and other vegetable oils which have already attained a high degree of perfection are constantly undergoing improvement.

Towards the end of last century the introduction of improved methods in the making of margarine rendered it possible to use both these oils in their refined state, with the result that an immediate and remarkable development in their use for this purpose took place. The increase in their consumption for this purpose was extremely rapid, and within a few years a very large proportion of the whole of the world's production of coconut oil and palm-kernel oil was diverted from the soap pan to the margarine churn. This movement received a further impulse during the Great War, and it is no exaggeration to say that one of the decisive factors in bringing about the result of the War was the possession by the Allies of the sources of supply in West Africa of palm kernels and ground nuts, and from India and Ceylon of copra. Until the eighties cotton oil was practically unknown as an edible oil, but as science in refining oils progressed, its quality was recognized and, consequently, added enormously to the supplies to meet the ever-increasing consumption. The supplies of copra have steadily advanced during recent years. In 1900 the world's supply totalled about 189,000 tons, and it may be said they now approach 900,000 tons per annum. Coming to recent times, soya-bean oil, introduced in Europe about 1910, is purchased to-day to the extent of about 25,000 tons in Europe, besides a much larger production in the East.

It is interesting to note in passing that rape and linseed oil, which were used for edible purposes over one hundred years ago, and after their consumption

had fallen practically into disuse, are now again (when price permits) used as edible oils, but principally in the hydrogenated or hardened state. The edible trade steadily encroaches on every fresh source of supply, the most recent being palm oil, which is now being more freely used for edible purposes. Until recently we have depended entirely on West Africa for the supply of palm oil, the exports from that country being about 90,000 tons per annum. There has been no system of cultivation or preservation in West Africa. The natives have collected the palm fruit from the wild trees in the forest and have, in a primitive way, extracted the oil from the outer husk or pericarp. However, it is now recognized that West Africa must begin to face a serious competitor in the cultivated oil-palm plantations in Sumatra. According to reports, within the next ten years the export of palm oil from that country should be approaching the same quantity as now exported from West Africa. Systematic cultivation of the oil palm will enable Sumatra to produce two or three times the quantity of fruit that is obtained in West Africa from untended trees, while the systematic collection of fruit and manufacture of oil by efficient machinery will produce larger yields of oil of better and more uniform quality than are obtained by native methods.

The Colonial Office and merchants interested in West Africa are realizing what they have to face, and a committee, comprised of officials and merchants, was recently appointed to report on the position and put forward recommendations for the safeguarding of this important industry in West Africa. The time is not far distant when the oil palm in West Africa will have to be cared for and proper steps taken to cultivate it, also to introduce machinery for the extraction of the oil—in fact, to bring the collection of this valuable product in West Africa up to date and on a business footing. There is a great future before palm oil, now that it can be refined and used for edible purposes.

The process of hardening oils is claiming the supply of every vegetable oil produced, and a new source of supply may be expected in a few years to come from the shea nut. It has been stated by the Government authorities of the Gold Coast that in Ashanti and Northern Territories some 200,000 tons of these nuts can be collected and marketed annually directly an economical means of transport is provided to bring this supply to the port of shipment at a reasonable cost.

The fishing industry is again becoming of great importance. Whale-oil production at the end of last century had fallen to about 20,000 tons annually. However, with improved methods of fishing, and with fresh seas broached, whale-oil production to-day varies from 80,000 to 120,000 tons annually.

It is noticeable that the seed-crushing industries, like others, once established, tend to remain in given countries or districts: cotton-seed crushing in the United States; palm kernels in Germany; copra, sesame seed, and ground nuts in France, Germany, and Holland. To some extent this may be due to the conservative nature of the farmer, who, once he is accustomed to a given sort of cake for his cattle, does not change readily. The War forced many changes, and as it was not possible to find an outlet in Germany for palm kernels and ground nuts, these products came to this country, with the result that, at the present time, about 200,000 tons of palm kernels and 100,000 tons of ground nuts are crushed here.

This industry, founded during the War, has remained, thus showing that extraneous influences are, in some cases, necessary to assist in the starting of industries.

In view of the world's expanding population and the impossibility of increasing the supply of natural butter sufficiently, the necessity is apparent of encouraging supplies of oil seeds in order to produce oil for the manufacture of margarine. Undoubtedly, the production of the British Empire could be largely increased. This particularly applies to copra, cotton-seed, ground nuts, and linseed. During the past twenty-five years supplies of vegetable oils used for edible purposes have increased over 50 per cent. against an increase in the population of about 30 per cent., thus indicating that vegetable oils are steadily replacing butter, and undoubtedly the tendency will be, the world over, for the consumption of margarine per head of population to increase, and the consumption will concentrate on vegetable margarine. The production of animal fats of all sorts is limited; grazing possibilities are restricted, but, as already stated, the supplies of vegetable fats can be greatly increased. The demand for oils and fats for technical purposes has not increased in the same ratio as the demand for edible purposes.

It is for the British and Colonial Governments and their experts to see how best increase of supplies can be brought about, and it is for business men to use their best endeavours to this end, that increased supplies find a useful and economical outlet.

The scope of the present volume is a very wide one, and the authors' task has, therefore, been one of no small magnitude. Work of this kind involves the consideration of much information of a commercial, technical, and statistical character relating to a wide range of products of very varied nature, and necessitates experience possessed only by those who, like the present authors, have been for many years in intimate contact with the subjects dealt with.

J. H. BATTY.

March, 1924.

AUTHORS' PREFACE

ALTHOUGH we are well aware of the truth of the often-quoted proverb *Qui s'excuse s'accuse*, we feel it necessary to tender our apologies for omissions of which we know and also for errors of omission or commission which are certain to be discovered by readers of this volume.

The work covers a very broad field in the geographical sense, as well as in subject-matter, and has perforce been compiled within a limited time—which, moreover, could not be devoted solely to this object—and also within a limited space, and on the more or less rigid scheme of arrangement necessitated by the scope of this Series.

The production, exploitation, and commercial utilization of oilseeds and their products are all matters involving a high degree of technical knowledge and skill; in considering these questions we have endeavoured as far as possible to avoid the use of technical language and have omitted any detailed descriptions of technical processes, except where such are essential to a clear understanding of the subject dealt with.

The collection and co-ordination of the large mass of information necessary for the compilation of this book has given a new aspect to several questions and brought to light various unsuspected features in the trade of the Empire in oil-seeds and their products. In directing attention to such points we hope that the book will have fulfilled a useful purpose and that some, at any rate, of the questions may eventually be solved satisfactorily.

Our work has brought us in contact with so many who have lightened our labours by supplying information, assistance, and advice, that it is impossible to thank all who have helped us; we must, however, acknowledge our indebtedness to Mr. H. A. F. Lindsay, C.B.E., I.C.S., Indian Trade Commissioner, for his timely help in supplying information and for reading our manuscript relating to Indian products; to Mr. Hugh Trenchard, A.C.A., secretary of the London Oil and Tallow Trades Association, and Mr. W. H. Fenwick, secretary of the Incorporated Oilseed Crushers' Association, for information on the activities of these Associations; to Mr. Faure, who has provided us so liberally with information from his very large collection of statistics relating to our subject; and to various members of the staff of the Imperial Institute for much useful advice and information. Last—and by no means least—our thanks are due to Miss D. G. Hewer, B.Sc., whose energetic assistance in the collection of data and in writing many sections of this book has been most helpful.

E. R. BOLTON.
R. G. PELLY.

TECHNICAL RESEARCH WORKS, LIMITED,
LONDON, S.W. 3.
March, 1924.

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OILS, FATS, WAXES, AND RESINS

OILS, FATS, WAXES, AND RESINS

PART I

OILS, FATS, WAXES, AND RESINS

OILS AND FATS

DEFINITIONS, CLASSIFICATIONS, AND USES.

THE term "oil" is one which has, unfortunately, been applied to a variety of liquids of somewhat similar appearance and physical character, but differing widely in chemical character—viz., petroleum oils, volatile oils, and "fixed" or fatty oils.

Petroleum oils are essentially hydrocarbons (*i.e.*, compounds of hydrogen and carbon), and fuel oils derived from petroleum are dealt with in Volume VI. of the present Series, while hydrocarbon lubricating oils are dealt with in a special section of Part III. of the present volume; the essential or volatile oils (used chiefly for perfumery and flavouring essences) are composed of compounds of widely varying chemical nature (see Volume VII.); the fixed or fatty oils, with which oils alone this section of the present volume is concerned, are all composed of compounds of glycerol (glycerin) and fatty acids known to chemical science as glycerides. Tristearin, $C_3H_5(C_{18}H_{35}O_2)_3$ or $C_3H_5 \begin{cases} O\cdot OCC_{17}H_{35} \\ O\cdot OCC_{17}H_{35} \\ O\cdot OCC_{17}H_{35} \end{cases}$, may be taken as a typical example of a simple triglyceride.

The relative technical importance and the various uses of the different fatty oils depend to a very great extent on their chemical composition and behaviour,* and it is to variations in the chemical and physical characters of the many common fatty acids (occurring as glycerides) that different oils owe their distinctive character. For example, olein and linolein, the glycerides of oleic and linoleic acids respectively, are liquids, and therefore oils in which these substances are the chief constituents (*e.g.*, olive and soya-bean oils) are liquid; stearin and palmitin are glycerides of solid fatty acids of comparatively high melting-point, and oils containing large amounts of these glycerides (*e.g.*, tallow, palm oil) are solid in temperate climates and are commonly classed as fats.

It might be noted here that the term "fat" applied to a solid oil is a somewhat loose one; for example, coconut oil, which is liquid in the tropical countries of origin, becomes solid in Europe, at any rate during the cooler part of the year, and would then be classed as a fat.

* The chemistry and technology of oils is fully dealt with in various textbooks referred to in the bibliography.

In addition to containing glycerides of several different kinds of fatty acids, oils may contain what are known as "mixed triglycerides"—*i.e.*, glycerides in which the glycerol is combined with three molecules of two or three different fatty acids; this is a somewhat difficult point to make clear in non-technical language, but one might consider a simple example: suppose an oil were found to contain only oleic and stearic acids united to glycerol, if only *simple glycerides* were present we should have a mixture of triolein and tristearin, but if *mixed triglycerides* were also present one might have oleo-distearin and stearo-diolein in addition to triolein and tristearin.

The influence of such mixed triglycerides on the character of oils—particularly on such properties as consistence and texture—which are most important factors in edible oils—is great, and is often not recognized as fully as it should be.

An important chemical property, possessed by certain fatty acids such as linolic and linolenic acids, is the power to absorb oxygen from the air; oils, such as linseed oil, containing chiefly glycerides of these acids form a firm, tenacious film or skin on exposure to air, and are consequently known as drying oils.

It will be seen that oils may be classed broadly in groups according to their characteristic properties (upon which their uses depend) in the following manner:

Group.	*Typical Oil.*	*Typical Uses.*
Drying oils.	Linseed oil.	Paint, varnish, linoleum.
Semi-drying oils.	Soya bean.	Edible oils, soap.
Non-drying oils.	Olive oil.	Food, soap.
	Castor oil.	Lubrication, soap.
Fats (*i.e.*, oils solid at ordinary temperature).	Lard.	Food.
	Tallow.	Soap, candles.

It is evident that drying oils are naturally fitted for the manufacture of paints, varnish, and linoleum, and the fact that such oils are liable to change renders their use in edible products undesirable, although they can be, and are to some extent, used in edible products; again, their capacity for absorbing oxygen with consequent thickening or "gumming" obviously renders them (and also the semidrying oils to a less extent) unsuitable for lubricating purposes.

The non-drying oils and solid fats, which are but little susceptible to change on exposure to air, are obviously suited for use as food or as lubricants.

Soaps may be made from all the fatty oils by treatment with caustic alkali, glycerin being an important by-product of soap manufacture, the character and consistency of the soap depending largely on the melting-point of the fatty acids present in the oils used.

The solid oils or fats, such as tallow and palm oil, are of particular interest to the candle-maker as sources of fatty acids of high melting-point.

Modern science has placed in the hands of the oil technologist a most valuable weapon—the process of hardening oils by hydrogenation—by means of which liquid oils may be converted into solid oils of any desired degree of consistence or melting-point (within wide limits), whilst at the same time the oil is frequently deodorized and bleached; this process has enabled liquid oils of poor colour and unpleasant smell, such as whale oil, to be converted into solid fats suitable for soap and candle manufacture and often even for use in edible products.

Sources of Oils.

Oils and fats are widely distributed in nature in plants, animals, and fishes; in plants oils occur chiefly in the seed kernels, but the fleshy pulp of some fruits —*e.g.*, olives and palm fruits—is also oleaginous; in marine animals such as the whale, oil is present chiefly in the blubber; in terrestrial animals fatty tissues occur in various parts of the body; in many fishes the liver is an important source of oil (*e.g.*, in the cod), but in other cases (*e.g.*, the salmon and herring) the flesh is oily.

Oil is also present in many of the lower forms of life, such as the yeasts and even in bacteria; in fact, attempts have been made to utilize yeast as a source of oil.

The occurrence of oil in plants is practically limited to the fruit, and in the majority of cases the seeds or seed kernels are the source of oil, though some fruits—*e.g.*, the olive—are furnished with an oily pericarp or outer pulp surrounding the seed.

Where both the outer pulp and inner seed kernel are oily, it is interesting to note that the oil from the outer pulp generally differs widely in character and composition from that of the kernels. This is particularly marked in the case of the fruit of the oil palm, where the pulp furnishes palm oil, a bright orange-coloured oil which is practically devoid of lauric acid, whilst the kernels furnish a colourless oil in which lauric acid is the predominant constituent.

Commercial oilseeds are obtained from plants belonging to many of the different Natural Orders, and it is a curious fact that, although allied plants of the same Natural Order may furnish oils of very similar character, they frequently do not do so For example, the Natural Order Euphorbiaceæ includes castor seed, yielding a non-drying oil of almost unique character and composition, and also includes various species of *Aleurites* (such as *A. cordata* and *A. Fordii*), yielding tung or China wood oil, an oil with very marked drying properties.

Oils derived even from seeds of plants of the same genus sometimes differ widely in character; for example, the oils derived from the species of *Aleurites* mentioned above differ markedly in composition from the oil of *A. moluccana*, known as candle-wood oil.

Manufacture of Oils and Oilcakes.

On a commercial scale oil is obtained from oilseeds by two methods—by expression or by extraction by solvents. The first method is one practised from early times by native races in many countries, the seed being ground in mortars and the ground material pressed in crude wooden wedge or screw presses; these methods are still in use in such countries as China and India, while even simpler methods—*e.g.*, boiling the ground seed with water and skimming off the oil—are also employed.

It is not possible, owing to space, to give here any detailed description of modern large-scale methods of oil manufacture, but an outline of the more essential steps is desirable.

1. The seed is subjected to sifting process to remove dust, stones, foreign *seed, and fragments of iron are removed by magnetic separation.*

2. The seed is in certain cases decorticated—i.e., the shell or husk is removed. This is desirable, as husks and shells are devoid of oil, cause reduction in yield of oil, reduce the value of the oilcake for feeding purposes, and in most cases also affect the quality of oil produced.

3. The cleaned seed or decorticated kernels are ground either in edge-runner mills or more usually in roller mills. The choice of method of grinding and the setting of the rollers necessitates considerable experience and skill, as different methods are required for the various kinds of material to be treated, and also because the character of the ground material required depends on the subsequent treatment it is to receive—for instance, whether the oil is to be expressed from the ground material or extracted by solvents.

Oil Expression.

The oil is expressed from the ground material, the method and machinery employed depending to a large extent on the kind of material being worked. In many cases the material is first cold-pressed to obtain an oil of high quality, and the resulting cake is then reground and hot-pressed so as to reduce the amount of oil left in the cake to a minimum. The hot-pressed oil is generally darker in colour and less free from impurities than cold-pressed oil.

The presses used for expressing oil operated by hydraulic pressure are of two types, Anglo-American presses and cage presses. In the former the ground material—previously subjected to light pressure in a cake-former or moulding machine to produce a cake which may be handled easily—is wrapped in stout cloth (" press bagging," which is made from various fibres such as camel hair), and placed between stout corrugated metal plates, fitted one above the other between the head of the ram and the top casting of the hydraulic press. On applying pressure gradually by means of the ram the oil is squeezed out of the ground oilseed, passes through the press bagging, and is collected. The press bagging serves the purposes of retaining some of the fine meal and also of affording an easy passage for the oil, which would otherwise have to pass through considerable distances of the dense cake to reach the outer edges of the cake. The corrugations on the press plates serve to prevent undue spreading of the meal during pressure; the pressure applied naturally varies with the material being worked, but is very considerable, two-thirds of a ton per square inch of the cake being quite usual.

In presses of the cage type the previous formation of a cake is avoided and the use of press bagging is decreased. The cage consists of long rolled-steel bars, the ends of which fit into annular spaces of two castings, thus forming a kind of cylindrical box. The adjacent faces of the bars fit closely together, but are lightly machined at short intervals so as to give narrow spaces $\frac{1}{4000}$ to $\frac{1}{64}$ inch) to allow the passage of oil without that of meal. The bars are fitted outside at intervals with strong steel bands to enable them to stand pressure without distortion. In some cases a cylindrical vessel made of sheet steel perforated with very small holes is used in place of the cage built up of bars.

In working the press successive quantities of meal are placed inside the cage, metal plates and sheets of press bagging being placed between each batch of meal. When the cage is filled, pressure is applied by the hydraulic ram, the head of which moves upwards inside the cage. The pressure at the top of the cage is borne by an extension of the top of the press, which also fits inside the cage so as to allow the whole cage to rise, and obviate difficulties introduced by the cakes adhering to the cage owing to the high pressure. The cage during pressure is surrounded by a sheet metal jacket to prevent loss of oil. Cage presses possess the advantages of enabling a high pressure to be used—as much as 3 tons per square inch on the cake—which is much higher than can be obtained in Anglo-American type presses, and also of utilizing less press bagging, the wear and cost of which are considerable.

Another type of machine is also largely employed both in this country and America—viz., the Anderson expeller; in this machine the meal is fed continuously to the machine and forced through a long cylindrical chamber by a helical screw of varying pitch; the meal is thus subjected during its passage through the cylinder to considerable pressure regulated by a choking cone at the outlet. The oil is thereby expressed and passes through perforations or slots in the cylinder, the meal being carried through to the outlet. These machines possess the advantage of obviating the use of press bagging and of operating continuously with a reduction in cost of labour for supervision, but are not very suitable for use with very soft oily seed, though they are used with success for the first pressing of very oily material such as copra.

The Anglo-American press system is generally more suited to work material with a moderate oil content (as very oily seed tends to " spew " at the edges of the cake), cage presses being employed largely for seed of high oil content.

Speaking broadly, oilseeds may be divided into two classes: those dealt with by a single expression, such as linseed, cotton seed, and sesame seed; and those requiring two expressions, such as copra and palm kernels. In the case of seed of the latter type a cage press or an expeller may be used for the first pressing and Anglo-American presses for the final pressing.

Solvent Extraction.

For some years past enormous quantities of oil have been manufactured in this country and on the Continent and elsewhere by extraction of the ground seeds with volatile solvents, and several efficient plants of British manufacture are now obtainable. In general petroleum spirit of low boiling-point (80° to 120° C.) is the best and most popular solvent, though other solvents, such as benzene (benzol) and carbon bisulphide, are also employed, while solvents such as carbon tetrachloride and trichlorethylene, which possess the advantage of being non-inflammable, are favoured by some manufacturers. The process is essentially a simple one, consisting merely in treating the meal with successive lots of solvent until sufficiently extracted in large vessels generally filled with stirrers to promote even mixing of solvent and meal, and to prevent " channelling " of the mass, and with filtering devices to separate fine meal from solvent.

The solvent is removed and recovered for reuse by evaporating the oil-solvent extract, while the extracted meal is steamed to remove solvent. The solvent process in some cases possesses advantages over expression in labour, power, and fuel consumption, and enables a higher yield of oil to be obtained.

If the solvent extraction process is carried out skilfully in properly designed plant no traces of solvent should be present in either the oil or extracted meal.

In contradiction of the frequent statements that have appeared in the past, to the effect that extracted oils are unsuitable for edible use, it may be said that enormous quantities of edible oils have been made for years past by extraction processes, and that such oils are of excellent quality, in some cases even superior to expressed oils.

Refining of Oils.

It would be quite impossible to give any very detailed account of the various methods employed in refining oils; all that can be done is to sketch briefly a few of the more general methods. The refining of an oil often calls for a high degree of technical skill and scientific knowledge, and though a good deal of success has been attained by "rule-of-thumb" methods in many cases, it is fairly obvious that better and more certain results are attainable by strictly scientific methods such as are now being employed to an ever-increasing extent. It is, perhaps, not too much to say that each particular kind of oil needs a certain method of treatment, and even that these methods must be varied to suit different batches of an oil and also to suit the purpose to which the refined oil is to be put. Not unnaturally many oil-refiners employ and regard these methods as "trade secrets," though, as a matter of fact, such "secrets" are often widely used and well known to other manufacturers.

Crude oils—whatever the method of preparation—are liable to contain impurities such as fine meal in suspension, water, mucilage, and free fatty acids.

Mere storage of the oil in tanks results in the settling out of water, fine meal, and mucilage, after which the clear oil can be run off. Where time and storage space must be saved the removal of such impurities can often be hastened by treatment with sulphuric acid, which chars and precipitates the non-fatty matter, or, if the use of acid is not desirable, the oil can be filtered after agitation with fuller's earth or kieselguhr.

Dark-coloured oils—*e.g.*, palm oil—are often bleached by oxidation, either by means of air or by chemical oxidizing agents.

Free fatty acids are removed by treatment with alkali (generally caustic soda), but for many technical purposes small amounts of free fatty acid do not detract from the value of the oil.

In the refining of oils for edible purposes the requirements are very much more stringent than in the case of oils required for technical purposes; edible oils must be devoid of free fatty acid, free from unpleasant odour or taste, of pale colour, and *above all must not deteriorate* when stored for considerable periods.

Generally the process of refining edible oils consists in:

1. *Neutralization and Removal of Free Fatty Acid.*—This is effected by treat-

ment of the oil with caustic soda solution in measured excess of that required to combine with the free fatty acids present. The conditions of neutralization vary with different oils—even with different grades of the same oil—and need not be discussed in detail. Briefly the fatty acids are converted into soap, which is separated; the treatment with alkali frequently also removes much colouring matter.

It is important to note that the separated " soap stock " always carries with it a considerable amount of neutralized oil; roughly speaking, the " refining loss " (soap and oil, etc) is about twice the original percentage of free fatty acid, so that it is not commercially possible to refine oils containing large amounts of free fatty acids. The " soap stock " obtained is either used direct for soap manufacture or is decomposed with mineral acid and sold as " acid oil " for use in soap and candle manufacture.

Free fatty acids in oils may also be converted into neutral glycerides by treatment with the requisite quantity of glycerol (or of mono- or di-glycerides) under suitable conditions;* oils containing free fatty acids may thus be rendered neutral *without the removal* of free fatty acids.

2. The neutralized oil free from soap and alkali is then decolorized by agitation with fuller's earth or special " bleaching " charcoal (or a mixture of both) and filtered to remove the decolorizing agent.

3. The refined oil is finally deodorized by treatment under vacuum with superheated steam.

Edible oils are also frequently " demargarinated,"—that is, the oil is chilled so as to cause crystallization of the glycerides of higher melting-point (commonly called " stearines "), which are then removed by filtration. This process is carried out in order to obtain an oil which will remain clear and liquid when exposed to low temperatures such as occur in winter.

By chilling and pressing solid fats, such as coconut and palm-kernel oil, large quantities of " stearines " of firmer consistence and higher melting-point than the original whole oil are manufactured; these " stearines " are largely used in chocolate manufacture.

Fat-Splitting and Distillation of Fatty Acids.

Fat-Splitting.—These processes are much used for the manufacture of fatty acids for candle and soap manufacture, and are chiefly employed for tallow, palm oil, low-grade fats, and " acid oils " such as " cotton black grease." The process known technically as " fat-splitting "† consists in decomposing the neutral glycerides into glycerol and fatty acid, and may be effected in various ways; " splitting " is essentially a process of hydrolysis or saponification.

1. Saponification by means of bases, by heating with water and about 3 per cent. of a base such as magnesia or lime; this process is generally carried out in large copper autoclaves under considerable steam pressure; after saponification the aqueous liquor containing the glycerol is separated, and the glycerol recovered by distillation, while the lime soaps formed are decomposed by sulphuric acid.

* English patents 159,587 and 163,352. † *Journ. Soc. Chem. Ind.*, 1923, 42, 51 T.

2. *By acid saponification: (a) By treating the oil heated to about 120° C. with 4 to 6 per cent. of concentrated sulphuric acid, followed by decomposition of sulphonated compounds by boiling with water.*

(*b*) By means of one of the several patented fat-splitting reagents, such as those of Twitchell, which consists of sulpho-compounds of fatty acids and aromatic hydrocarbons, this process is carried out by heating without pressure in lead-lined vessels.

3. By means of enzymes. Many oilseeds contain natural fat-splitting enzymes or lipases which decompose glycerides at low temperatures. Although a considerable amount of work has been done on the technical splitting of fats by castor seed lipase, it does not appear that the process has been widely adopted.

The process of acid saponification mentioned above [2 (*a*)] yields fatty acids of very dark colour which must be purified by distillation, but is of particular value to the candle-maker, as the yield of "stearine" is increased, owing to conversion of part of the liquid oleic acid into solid acids, which does not occur in the other processes.

If raw material of good colour has been used and splitting effected by a process (*e.g.*, that mentioned under 1 above) which does not cause appreciable darkening of the fatty acids, these may be used direct without further purification by distillation (see below).

The solid acids produced from saponification fatty acids, by crystallization and removal of the liquid acids (oleine, oleic acid), by pressure, are known commercially as "saponification stearine."

Low-grade fatty acids of dark colour are purified by distillation as described below; separation of stearine ("distillation stearine") and oleine in these cases may be effected by fractional distillation as well as by pressing.

Distillation* of fatty acids (after previous washing to remove mineral acids) is carried out generally in cast iron fire-heated stills with the aid of live superheated steam and vacuum. In some cases—*e.g.*, in America—oil fuel or gas heating has been applied successfully. The distilled fatty acid vapours are generally condensed in copper water-cooled condensers.

The colour, smell, and general character of the distilled acids depends on the nature of the raw material, the degree of splitting of the fat (*i.e.*, the relative amounts of fatty acid and unchanged oil), and also largely on the plant used for distillation and the efficiency of working.

Frequently a series of stills is used the working of any one of which is discontinued when it contains too much pitch to be efficiently worked.

The once-distilled fatty acids are often further purified by redistillation, and are generally separated by fractional distillation or and by crystallization and pressing into solid acids (stearic acid or "stearine") and liquid acids (oleic acid or "oleine"); these commercial fatty acids are not chemically pure—*e.g.*, stearic acid consists chiefly of an admixture of stearic acid and palmitic acids, and their character naturally depends on the raw materials used and the process

* "Operation of Fatty Acid Distillation Plants," O. H. Wurster (*Chem. and Metall. Engineering* 1921, **25**, 651).

of manufacture. "Oleine" is chiefly employed in soap manufacture and also in wool spinning. "Stearine" is chiefly used for candle manufacture.

These processes of conversion of fats into fatty acids are of great technical importance for the recovery of glycerol and for producing material of good colour suitable for use in soap and candle manufacture from low-grade oils and fatty materials (such as bone grease, cotton "acid-oil" or "black grease") which could not otherwise be utilized.

Oil Hydrogenation (Hardening).

The conversion of liquid oils to hard fats by hydrogenation* is based on the classic researches of Sabatier and Senderens; the process was first employed on a technical scale some twenty years ago and has rapidly become of enormous importance in the oil industry.

The process is based on the fact that liquid oils are largely composed of glycerides of unsaturated acids, which are capable of uniting directly with hydrogen under certain conditions with the formation of solid fatty acids; for example, oleic acid is converted to stearic acid.

$$\underset{\text{Oleic acid.}}{C_{18}H_{34}O_2} + \underset{\text{Hydrogen.}}{H_2} = \underset{\text{Stearic acid.}}{C_{18}H_{36}O_2}.$$

Technically the process generally consists in heating the oil and agitating with hydrogen gas under pressure in the presence of a very small amount of a nickel powder catalyst; the degree of hardening being controlled by various conditions such as time, temperature and pressure, amount of catalyst, and depending on the degree of conversion of the unsaturated acids (present as glycerides) to saturated acids. After hydrogenation to the required degree the nickel catalyst is removed by filtration in filter presses.

Many different metals have been tried as catalysts, but technical processes nowadays employ almost exclusively nickel catalysts, prepared generally by precipitation of nickel carbonate on some inert support such as kieselguhr; this precipitate is carefully washed and dried and reduced by heating in hydrogen before use.

Although essentially simple, the success of the process depends on a great many factors, such as the activity and life of the nickel catalyst, efficient agitation of oil with hydrogen and catalyst, and—very largely—on the purity of the oil treated and of the hydrogen used.

Oil hydrogenation has been the subject of a great number of patents and also of much scientific investigation. Although hardening of various oils has been carried on for many years past on an enormous scale, it is only in recent years that much attention has been directed to such important questions as the influence of conditions of hydrogenation on the chemical nature of the fatty acids produced† during hydrogenation or the effect of different fatty acids on the character and value of hardened fats for various purposes.* It is quite evident that the field

* *Fats, Natural and Synthetic*, W. W. Myddleton and T. H. Barry.

†**E.g.*, E. J. Lush, *Journ. Soc. Chem. Ind.*, 1923, **42**, 219 T; 1924, **43**, 53 T.

for further research is a wide one, and that there is also still room for improvement in the technique of the process; at present the processes used are discontinuous; spent catalyst must be removed by filtration and cannot be recovered economically. A process in which simple plant can be employed, through which the oil can be pumped continuously over a rigid stationary metallic nickel catalyst, and which avoids filtration of oil after hydrogenation, would obviously be of great technical importance.

The advantages of such a process were foreshadowed by one of the present authors* in 1923, and the complete process has now been fully developed and is in successful operation on a technical scale in London.

The process consists simply in pumping oil (or allowing it to flow) over activated metallic nickel contained in a tubular vessel filled with hydrogen under pressure, the degree of hydrogenation being controlled by the speed of flow of oil. Activation and reactivation† of the nickel catalyst without loss is effected cheaply by oxidation by means of an electric current in simple plant. The catalyst retains its activity over long periods and serves for the hydrogenation of low-grade oils such as cannot be treated economically by means of processes using powder catalysts. This continuous process shows considerable saving over existing processes, owing to simplicity of plant and low cost of labour and working, and avoids the necessity of removing catalyst from the hardened oil by filtration; these advantages, together with the fact that the chemical nature of the products can be controlled at will by simple modifications of methods of running the plant,‡ indicate that this process should rapidly supersede existing discontinuous processes employing power catalysts.

COMMERCIAL VALUATION OF OILSEEDS AND OILS

It would be quite outside the scope of the present volume to deal in any detail with the increasingly wide application of scientific methods to the commercial analysis and examination of oilseeds and oils and allied products. It is, however, desirable to indicate briefly some of the more important factors involved, as many non-technical men, such as merchants, brokers, and shippers, come more or less frequently in contact with analytical reports on oilseeds and oils. It is hoped that the following notes may serve to indicate broadly the meaning of the various features of such reports.

The valuation of consignments of oilseeds is a comparatively simple problem and depends on determining whether the particular consignment is of fair average quality. As a general rule the following points must be dealt with:

1. Presence of foreign seed or undue proportions of other materials, such as husk, shell, or dirt, the proportion of which is usually fixed by contract.

2. Condition of seed; thus, seed may have heated during transit with consequent damage to the oil and cake manufactured from the seed—*e.g.*, copra is often damaged by smoke during drying, or a consignment described as sun-dried copra may contain kiln-dried copra.

* E. R. Bolton, British Association. † English patent 203,218, 1922.
‡ E. J. Lush, *Journ. Soc. Chem. Ind.*, 1923, 42, 219 T.

3. Excessive moisture—of importance as influencing the yield of oil and also ease of grinding the seed.

4. Amount and quality of oil in the seed; some oilseeds—*e.g.*, palm-kernels—are sold on a definite basis of oil content with definite agreed allowances below or above the fixed percentage. The character of the oil obtainable from a consignment—as determined by the amount of free fatty acid present, by the colour, and by the ease of refining—will in some cases have to be taken into account.

The valuation of oils and fats is a more complex task, calling in many cases for the application of highly scientific methods of examination and a wide knowledge of the nature, sources, and utilization of raw materials and manufactured products. The following points have generally to be considered in the case of crude oils:

1. Presence and amount of non-fatty matter, involving the determination of moisture and of "dirt"—*i.e.*, substances insoluble in an oil solvent (generally petroleum ether is used, but other solvents are used in certain cases, and the nature of the solvent should be stated). Contracts for sale of oils, in many cases, specify definite allowances for moisture and for dirt. Moisture is determined by the loss in weight obtained on drying the oil or fat; in most cases the loss at 100° C. is determined, suitable precautions being taken to avoid oxidation of drying oils (*e.g.*, linseed oil). In the case of oils containing volatile acids—*e.g.*, coconut and palm-kernel oils, and particularly their "acid oils," drying at low temperature is necessary to avoid loss of volatile acids.*

For example, tallow and vegetable tallow is generally bought and sold in the United Kingdom on a basis of 1 per cent. of moisture and/or dirt, allowances for any excess over 1 per cent. being made at the invoice price of the consignment. The allowable amount of moisture and/or dirt in the case of certain other oils—*e.g.*, pressed coconut oil—is only 0·5 per cent.

2. Quality of oil—depending on the colour as determined under standard conditions against an arbitrary fixed scale (Lovibond tintometer), and *very largely* on the amount of *free fatty acids present*, and also on the quality of the oil obtainable on refining the crude oil.

The question of the free fatty acid content is one of extreme importance in many ways; for instance, a high content of free fatty acids is generally an indication of inefficient methods of manufacture of the oil or of its manufacture from damaged material, and is often connected with rancidity in oils and fats, though free fatty acids are not *per se* the cause of rancidity. The most important effect of free fatty acids is their influence on the loss in refining of oils by neutralization with alkali; speaking broadly, an oil or fat will suffer a refining loss (due to conversion of fatty acid to soap *and to the carrying down in the "soap-stock" of neutral oil*) of twice the original percentage of free fatty acid, so that oils containing large percentages of free fatty acid cannot be neutralized by this process without undue refining loss, or even, in some cases, cannot be treated at all.

The conditions of sale of crude oils vary naturally with the kind of oil and with the purpose to which it is to be put, but sale contracts, in many cases, specify definite allowances above or below a fixed percentage of free fatty acids. For

* *Report of Committee of Analysts, Ministry of Food, Oils and Fats Branch*, 1919.

example, in the case of pressed coconut oil, a basis of 15 per cent. of free fatty acid (as lauric acid) is taken and allowances in price at the rate of 3d. per hundred-weight are made for every 2½ per cent. of free fatty acid above or below 15 per cent.

Sometimes—*e.g.*, crude cotton-seed oil in America—the refining loss is determined by actual experiment on a laboratory scale under conditions similar to those employed in works practice. In some cases limits are also fixed for colour of the crude oil and also of the refined oil obtainable from it under standard conditions of experiment.

The question of free fatty acids is particularly prominent in the case of palm oils, which vary widely in free fatty acid content according to methods of manufacture (see p. 39).

3. Purity of the oil. The question as to whether a consignment of an oil or fat is what it purports to be or is adulterated with other oils or fats is naturally one of great importance. Crude oils are at all times liable to adulteration either at the place of manufacture or at intermediate stages before they reach the buyer, and this side of the problem naturally rests between buyer and seller, whose contracts will cover such eventualities. Refined oils are also adulterated or sold under false descriptions, in which cases the matter often comes within the scope of laws regulating the sale of foods in various countries. In any case, the question of deciding the purity of an oil lies with the chemist. For a description of the methods employed in the examination of oils and fats the reader is referred for details to the works on the analysis of oils and fats, such as those mentioned in the Bibliography (pp. 262 to 265).

Briefly the methods employed in the analysis of oil consist in determining various constants which depend on the chemical nature of the various constituent glycerides present, though in a few cases—*e.g.*, sesame oil, cotton-seed oil—oils possess certain characteristic reactions which serve for their detection.

The examination of an oil usually includes the following determinations.

Physical Characteristics.

Specific Gravity (*sp. gr.*)—*i.e.*, the weight of a unit volume of the oil compared with that of the same volume of water at a definite temperature—15°/15° C. generally for oils; 100°/15° C. is often used for fats.

Refractive Index.—When a ray of light passes through a transparent substance it is diverted from the straight path to a definite degree depending on the nature of the substance—*i.e.*, the ray is bent. The simplest illustration of this is afforded by the appearance of a stick plunged into water. The degree of refraction is accurately measured *at a stated temperature*—usually 40° C.—by one of the various types of refractometers. The Butyro-refractometer is very generally used for oils; this instrument gives readings in degrees on an *arbitrary scale* which are convertible to true refractive index, $(n)_D$, by tables. This is a much used test, particularly valuable as a rapid "sorting test."

Titer (or Titre) Test.—This represents the temperature of solidification of the fatty acids derived from an oil or fat, and is a useful indication of the hardness of the soap or of the fatty acids which can be manufactured from an oil or fat.

Determination of the titer consists essentially in observing, by means of an accurate standard thermometer, the temperature at which a definite amount of fatty acids contained in a glass tube of standard size (and enclosed in an outer jacket) sets or solidifies. *The test must be made under strictly uniform conditions.* At first the temperature of the warm melted acids drops, then rises sharply to a maximum —the titer point—as the acids set, and finally falls. The test is chiefly used for tallow, palm oil, and other soap and candle fats. Contracts for tallow generally specify a titer test of a stated degree Centigrade, with reduction at the rate of 0·2 per cent. in price for every $\frac{1}{10}$° C. below the titer fixed. In some cases—*e.g.*, vegetable tallow, a similar addition in price is allowed for every $\frac{1}{10}$° C. over the fixed titer.

Solidifying-Point (*Setting-Point*).—The temperature of solidification of the fat itself, determined in the same way as the titer of the fatty acids, is also useful.

Melting-Point.—Determination of the temperature at which a fat (or the fatty acids derived from it) melts is frequently of value in determining nature and purity of a sample. It is *essential* that the methods of experiment and apparatus employed *should be uniform* in all cases, while the previous melting of the fat and conditions of setting also influence the test. Generally speaking, different analysts or manufacturers employ slightly different methods modified to suit their requirements, though attempts have been made—*e.g.*, in America —to agree to " standard " methods.

Other physical tests, such as *Viscosity* and *Flash point*, are used (more generally with hydrocarbon oils, though sometimes for oils and fats, the former particularly for lubricating oils), while determination of *Optical activity* (the power to rotate the plane of polarized light) is of value in some cases.

Chemical Characteristics.

Free Fatty Acids.—The amount of free fatty acids present is a " variant " depending on the degree of splitting off of free fatty acid from the neutral glycerides. It is determined by measuring the volume of alcoholic potassium hydroxide (caustic potash) of known strength required to neutralize exactly the free fatty acids present (the fat is agitated with neutral warm alcohol during the titration, and neutrality is generally indicated by the production of a pink colour with phenolphthalein). Free fatty acid is expressed as per cent. oleic acid (molecular weight 282) in most oils and fats, but in the case of oils of the coconut and palm-kernel type as per cent. lauric acid (molecular weight 200); in the case of palm oils as per cent. palmitic acid (molecular weight 256).

Saponification Value.—The amount of caustic potash (KOH) required to convert the oil or fat to soap—*i.e.*, to hydrolize it completely according to the chemical equation:

$$\underset{\text{Oil.}}{C_3H_5\left\langle\begin{matrix} O.R^* \\ O.R \\ O.R \end{matrix}\right.} + \underset{\text{Potash.}}{3KOH} = \underset{\text{Glycerol.}}{C_3H_5\left\langle\begin{matrix} OH \\ OH \\ OH \end{matrix}\right.} + \underset{\text{Soap.}}{3KOR}$$

R=fatty acid radicle for sake of brevity.

It is determined by boiling an accurately weighed quantity of about 2 grammes of an oil or fat with an excess (25 cubic centimetres) of standardized alcoholic potash solution of about 4 per cent. strength until saponification is complete (half an hour generally). The excess of caustic potash is then determined by titration with standard acid, using phenolphthalein as indicator. The saponification value is recorded as milligrammes of KOH required for 1 gramme of oil (*i.e.*, if an oil has a saponification value of 195, 1 gramme would require 0·195 gramme of KOH).

Iodine Value.—This is a measure of the glycerides of unsaturated fatty acids—*i.e.*, acids which can combine directly with iodine by addition (not by substitution of iodine for another atom or radicle); speaking broadly, it is an indication of the drying power of an oil (which depends on the absorption of oxygen by the unsaturated acids). It is determined by treating a known weight of the oil dissolved in a suitable solvent (*e.g.*, carbon tetrachloride) with a large excess of a standard solution of iodine (there are two types of reagent in common use—viz., Hübl and Wijs; the latter is preferable owing to rapidity of working and good keeping quality). After standing for a sufficient time—depending on the reagent used and the type of oil under test—the uncombined iodine is estimated by titration with standard sodium thiosulphate solution. The iodine value is recorded as percentage of iodine absorbed.

Reichert-Meissl, Polenske, Kirschner Values.—These three are purely *empirical* figures, due to volatile fatty acids which are present in certain oils and fats, and are obtained by the distillation of the mixed fatty acids under *strictly standardized conditions* in apparatus of *standard size* and *construction*. Descriptions of these valuable methods cannot be given here.* It is sufficient to say broadly that the *Reichert-Meissl value* is due to the presence of volatile fatty acids readily soluble in water (such as are present in butter); the *Polenske value* to less soluble or almost insoluble volatile acids—*e.g.*, lauric acid (such as occur in fats of the coconut type); and the *Kirschner value* is practically a measure of the butyric acid present. These methods are of particular value in the analysis of butter and butter substitutes, margarine, and fats of the coconut type.

Unsaponifiable Matter.—Most oils and fats contain small amounts of constituents other than glycerides; these are estimated by extracting them after converting the oil or fat into soap. Certain natural fats generally contain notable amounts of unsaponifiable matter—*e.g.*, shea butter (see p. 36). Additions of hydrocarbon oils or paraffin wax to oils or fats are detected in this way, while detailed examination of the chemical behaviour of the natural unsaponifiable matter of oils and fats is frequently of value in determining whether material is of animal or vegetable origin.

The following tables of analysis will serve to show how the chief commercial oils and fats differ in character. The figures are chiefly taken from analyses† made over a period of many years in the laboratory of one of the present authors, and show the usual variations for each oil and typical analyses in most cases.

* *Fatty Foods*, E. R. Bolton and C. Revis. † *Ibid.*

	Specific Gravity at 15°/15° C.	Refractive Index at 40° C.*	Melting-Point of Fatty Acid.	Free Fatty Acids (per Cent. Oleic).	Saponification Value.	Iodine Value (Wijs).	Unsaponifiable Matter (per Cent.).
DRYING OILS:							
Linseed oil:							
Usual limits ..	0·931–0·938	70·6–73	—	Under 5	189–195	175–200	0·8–2·0
Typical sample	0·933	70·8	—	0·6	192·5	180·5	1·3
China wood oil:							
Usual limits ..	0·940–0·946	†	—	0·5–1·5 (sometimes up to 3·0)	191–195	165–185	0·5–1·2
Poppy oil:							
Usual limits ..	0·924–0·926	63–64·5	—	Usually under 10	192–196	130–138	About 0·5
Typical sample	0·925	63·3	—	0·8	194	135·6	—
SEMI-DRYING OILS:							
Rape-seed oil from Indian seed	0·913–0·917	59	19°–21°	Usually below 2	168–178	94–104	0·8–1·7
Cotton-seed oil:							
Usual limits ..	0·922–0·925	58–59	35°–38°	Varies‡	192–195	105–115	0·8–1·8
Typical sample‡	0·923	58·4	—	0·1 or under in refined oils	192·6	112	0·85
Soya-bean oil:							
Usual limits ..	0·924–0·926	62·5–63·5	26°–29°	Seldom over 3	190–193	130–136	—
Typical sample	0·925	62·9	—	1·4	191·8	133	1·0
NON-DRYING OILS:							
Olive oil:							
Usual limits ..	0·915–0·918	55–56	22°–27°	Crude up to 20	190–195	80–87	0·5–2·0
Typical sample..	0·917	55·3	—	Edible, 0·3–1·0	191	85	0·8
Sesame oil:							
Usual limits ..	0·922–0·924	59–60·5	25°–31°	Varies§	188–193	103–110	0·8–1·2
Typical sample..	0·9235	59·5	—	2·6	191·7	104	1·0
Ground-nut oil:							
Usual limits ..	0·916–0·918	55–57·5	27°–30°	Up to 20 (seldom over 10)	190–196	87–98	0·4–0·8
Typical sample..	0·917	55·5	—	5·2	193·8	91·2	—

* Zeiss Butyro-refractometer reading.

† Falls outside the scale of Butyro-refractometer R.I.$(n)^D$ 1·510–1·512 at 40° C.

‡ Oils such as cotton refined for edible use are generally practically neutral—0·1 per cent. F.F.A.; if stearine has been separated, the constants will be affected in some degree—*e.g.*, winter cotton oil will have an iodine value over 110.

§ Varies according to condition of seed and manufacture.

	Specific Gravity at 15°/15° C.	Refractive Index at 40° C.	Free Fatty Acids (per Cent. Oleic).	Saponification Value.	Iodine Value (Wijs).	Unsaponifiable Matter (per Cent.).	Titer Test (° C.).
Animal Oils and Fats:							
Whale oil:							
Usual limits	0·916–0·927	—	Very variable	179–188	90–130	1·4–3·3	About 23
No. 1 crude . . .	0·918	—	0·9	188·6	104	2·4	—
Lard	0·860–0·862*	49–52	0·1–0·8	193–199	57–66	0·2–0·4	—
Tallow, etc.:							
Beef tallow	—	47–49	Varies in crude	193–199	38–44	—	43–45
Premier jus	—	47–48	edible below	195–200	38–45	—	42·5–44
Beef stearine . .	—	46·5–47·5	1·0	192–197	18–25	—	48–51
Vegetable Fats:							
Palm oil: Usual limits	0·921–0·924	41–45	Soft oils about 12† Hard oils up to 80	198–202	41–45	—	43–45
Typical sample . .	—	42	48·2	199·2	42	—	—
Melting-point of oil: Crude oil very variable; refined, incipient fusion about 27°, complete fusion about 38°.							
Shea butter:							
Usual limits, crude . .	0·917–0·918	55·5–61·0	2 or upwards	180–190	57–63	5–8	About 52
Typical sample, refined	—	59·5	8·3	181	58·9	6·6	—
Melting-point of oil: Incipient fusion, 27°–35°; complete fusion, 38°–41°.							

Coconut and Palm-Kernel Oils:	Specific Gravity at 99°/15° C.	Refractive Index at 40° C.	Free Fatty Acids (per Cent. Lauric).	Saponification Value.	Iodine Value (Wijs).	Unsaponifiable Matter.	Reichert-Meissl Value.	Polenske Value.	Kirschner Value.
Coconut oil:									
Usual limits	0·869–0·874	34·7–35·5	3–7 (crude)	256–258	7·9–8·8	0·15–0·3	6–8	15–17	1·6–1·9
Typical sample, refined	0·8698	35·5	0·09	257·3	8·6	0·18	7·5	16·5	1·8
Melting-point of fat‡ Incipient fusion, 20°–22° C.; typical sample, 22° C. Complete fusion, 23°–26° C.; typical sample, 26° C.									
Melting-point of fatty acids,‡ 22°–26°; typical sample, 25° C.									
Palm-kernel oil:									
Usual limits, crude . .	0·859–0·871	36–37·5	5–12	245–248	14–19	—	—	—	—
Typical sample, refined	0·870	36·8	0·10	246·8	15·0	0·22	5·2	9·8	1·1
Melting-point of fat:‡ Incipient fusion, 21°–24° C.; typical sample, 25·5° C. Complete fusion, 26°–29° C.; typical sample, 28·5° C.									
Melting-point of fatty acids,‡ 26°–29° C.; typical sample, 28° C.									

* At 99°/15° C. † As palmitic acid. ‡ Open capillary tube method.

The Sale of Oilseeds, Oils, and Fats.

On the Continent of Europe the markets of Marseilles in France, Hamburg and Harburg in Germany, Rotterdam in Holland, and Antwerp in Belgium are of great importance in the oilseed trade.

In the United Kingdom the chief markets dealing with these products are Liverpool, London, and Hull. Imports of West African produce of all kinds, such as palm oil and palm kernels and ground nuts, are of enormous importance on the Liverpool market. Hull is largely interested in the trade in cotton seed, linseed, and soya beans, in recent years with palm kernels also; while most kinds of produce, with the exception of palm oil, appear on the London market.

The chief centres of manufacture of oil and oilcakes are in Hull, Liverpool Warrington, London, Port Sunlight, and Manchester. Conditions regulating the sale of oilseeds and oils are laid down by such Associations as the following:

The Incorporated Oilseed Association, Exchange Chambers, St. Mary Axe, London, E.C.

The London Copra Association, 79, Leadenhall Street, London, E.C. 3.

The London Oil and Tallow Trades Association, 84, Leadenhall Street, London, E.C. 3.

The Liverpool United General Produce Association, Ltd.

The Hull Seed Oil and Cake Association of the Hull Incorporated Chamber of Commerce and Shipping.

The activities of such Associations have undoubtedly proved of the greatest value in suppressing adulteration of raw materials by specifying definite standards of quality, in fixing the terms of sale and delivery by definite forms of contract, and in regulating the settlement of disputes between buyers and sellers by arbitration. In many cases the standards of quality and terms of contract, etc., laid down by these Associations are of almost world-wide importance, being accepted in practically all other important countries with slight modifications to suit local needs. As an example the following brief notes* on the Incorporated Oilseed Association may be of interest:

This Association was instituted originally as the " Linseed Association " in 1863 with a view to remedy the unsatisfactory condition of the linseed trade brought about by the serious adulteration of linseed supplies to the United Kingdom. Adulteration to the extent of 15 or even 30 per cent. was met with, linseed being mixed with other seed, with the result that the yield and quality of the oil was affected adversely and the cake even rendered unfit for feeding. Enquiry was made into the regulations in force in the Marseilles oilseed trade, where the contracts were based on a fixed allowance of 4 per cent. of non-oleaginous substances and any oleaginous admixture was allowed for at one-half the price of the linseed, the amount of admixture being determined by properly qualified experts. As a result arrangements were made to control the English trade in linseed by similar regulations, and the " Linseed Association " was instituted for that purpose.

* We are indebted to the Secretary, W. H. Fenwick, Esq., for much useful information relating to the Association.

The success of this endeavour has led to the application of similar regulations to the trade in many other oilseeds, and at the present time the Incorporated Oilseed Association issues contracts for all the common oilseeds of commerce.

In the majority of cases the contracts for oilseeds specify that deliveries of seed shall be of "fair" average quality as indicated by comparison with "standard average" samples selected each month by experts of the Association. As an example the following salient points in contracts for La Plata linseed are of interest:

"Four per cent. basis. Sound delivered." "To be delivered at —— in sound and merchantable condition, subject to any country damaged grains in the Standard, and is warranted to be of fair average quality of the season at time of shipment, such average to be decided by the Standard Average of the Incorporated Oilseed Association for the month in which the seed is shipped."

"The percentage of admixture having been ascertained, non-oleaginous substances shall be considered valueless, and oleaginous as worth half the contract price of the linseed. The agreed standard of admixture shall be equal to 4 per cent. of non-oleaginous substances, but if the amount of admixture exceed it, the difference to be deducted from the contract price, or if less than 4 per cent. to be added to the same."

"If the seed is not equal to warranties, or is damaged by sea or otherwise, or is out of condition, the contract is not to be void, but is to be taken with an allowance to be fixed by agreement or arbitration."

Some seed—*e.g.*, East Indian linseed—is sold on a pure basis, allowances for impurities similar to the above being made, together with further allowance where less than 92 per cent. of pure seed is found.

The following are notes on some of the common commercial oilseeds:

Seed.	*Basis (per Cent.).*	*Allowances for Admixture.* At Contract Price (per Cent.).	At Double the Contract Price (per Cent.).
Linseed:*			
La Plata	4	Excess over 4	—
East Indian, Chinese	Pure	Up to 8	—†
Rape seed: East Indian, Chinese	"	" 3‡	Excess over 3
Sesame seed: East Indian	"	" 3	" " 3
Poppy seed: East Indian	"	" 4	" " 4
Castor seed: East Indian	"	" 2	" " 2
Soya beans: Manchuria	As specified	Excess over basis, as specified	—
Mowra seed: Bombay	3	Excess over 3	—
Ground nuts:			
Coromandel (decorticated)	2	" " 2	—
West African (in shell)	2	" " 2	—
Bombay (decorticated)	Pure	Up to 2	Excess over 2
Chinese (decorticated)	"	" 3	" " 3

* See p. 38; above also.

† If the percentage of pure linseed is below 92, an additional allowance to buyer equal to the excess of such admixture over 4 per cent.

‡ An additional allowances in the case of Indian rape seed is made for "Jamba seed" (*Brassica*, sp. wild rape, not true rape) up to 5 per cent. of Jamba seed allowed for at one-half the price of rape seed, over 5 per cent. valueless.

The sale of palm kernels and palm oil is regulated by the contracts of the Liverpool United General Produce Association.* Palm kernels are sold on a basis of 49 per cent. oil (extracted by petroleum ether) with allowance of 1½ per cent. on the contract price per ton for each 1 per cent. of oil under or over 49 per cent. or proportionately for any fraction of 1 per cent. The kernels are also to be of good merchantable quality; if inferior a fair allowance to be made; the quality is ascertained by cutting the kernels and examining them.

Palm oil is sold on a basis of 18 per cent. of free fatty acid calculated as palmitic acid, with allowance at 1s. 9d. per ton for each 1 per cent. over or under 18 per cent. and proportionately for any fraction thereof, together with allowance for all impurities (moisture and dirt).

The London Oil and Tallow Trades Association issues contracts for the sale of all kinds of oil derived from commercial oilseeds, for tallows, greases, and China vegetable tallow, Oriental fish oil and hardened Oriental soya bean and fish oils, and also for rosin and turpentine. In most cases the contracts do not fix any definite standards, but state that the oil shall be "of good merchantable quality." In the case of tallows and hardened oils standards of titer test and allowances are laid down (see p. 33), while dirt and/or moisture over 2 per cent. is generally allowed for at invoice price.

In pressed coconut oil up to 33⅓ per cent. of pressed palm-kernel oil is permitted and allowances of 3d. per hundredweight for every 2½ per cent. of free fatty acid above or below 15 per cent. (as lauric acid), together with allowance at contract price for over 0·5 per cent. moisture and/or impurities.

OILCAKES AND MEALS

The residues obtained on expressing the oil from seeds or kernels are obtained in the form of hard compact cakes—rectangular from Anglo-American, round from cage presses—and when the oil is extracted by solvents, as a more or less fine meal. The oilcake is sold largely in the form of whole cakes (which are broken up on the farm), or broken into fragments of convenient size, or as ground meal before sale. Extracted meal is sold as such or used for the manufacture of "compound cakes."

The composition of compound cakes is regulated by the manufacturer so as to produce cake having definite percentages of oil and albuminoids (protein) to conform to particular specifications, or to produce a feed specially attractive in taste, or suited to the requirements of animals of different species or age. Many different ingredients enter into the composition of compound cakes, the proportions and nature of these being varied by the manufacturers according to the relative current market prices of the different ingredients, but keeping the total percentages of important nutritive constituents, such as protein, oil, and carbohydrates, within specified limits.

It would be impossible to discuss at length the different ingredients used in

* The basis and allowances in contracts of the Incorporated Oilseed Association are identical.

compound cakes, but oilseed meal of various kinds, beans and peas, various grains (*e.g.*, oats and rice) and milling products such as bran, fish meal, blood, molasses, locust beans, and spices such as fenugrec are among the commonly used ingredients. Compound cake is often marketed in the form of small nuts or cubes of convenient size for feeding direct to animals.

It is not proposed to discuss here the principles of stock-feeding (see Vol. I.),* but, speaking broadly, the feeding values of oilcakes and meals depend on the percentages of protein or nitrogenous constituents, oil, digestible carbohydrates (such as starches and sugars), and on the indigestible fibre. The availability of these various constituents can be determined only by actual feeding experiments with animals; experiments of this nature have been made with all the well-known oilcakes and with the other more important feeding stuffs from which the factors of digestibility have been calculated.

In the scientific feeding of animals the amount of various feeds such as hay, roots, oilcake, etc., is adjusted so as to afford a definite ration of protein, oil, and carbohydrates suited to the age and weight of the animals and the conditions under which or purposes for which they are being fed.

A common practice used to arrive at an approximate estimate of the character and value of an oilcake or feed is to calculate the "nutrient ratio" and the "food units." The nutrient ratio is the relationship between digestible protein and carbohydrates and oil. For this purpose the percentage of oil is converted to its equivalent of carbohydrate, assuming 1 of oil to equal 2·4 of carbohydrate. For example, in a feeding stuff containing:

Digestible protein	10·2	per cent.
" carbohydrate	69·2	"
Oil	1·7	"

the ratio would be

$$\frac{(1{\cdot}7 \times 2{\cdot}4) + 69{\cdot}2}{10{\cdot}2} = 7{\cdot}2;$$

the nutrient ratio is, therefore, 1 : 7·2.

Food units are determined by adding the percentage of digestible carbohydrates to the sum of the oil + protein multiplied by 2·5 (*i.e.*, taking oil and protein to have two and a half times the value of carbohydrates); in the example above the food units would work out as follows:

$$69{\cdot}2 + 2{\cdot}5\,(1{\cdot}7 + 10{\cdot}2) = 98{\cdot}95, \text{ say } 99.$$

The following are typical analyses of commercial oilcakes and meals, the composition of different batches of oilcakes naturally varies to some extent, depending on the method and completeness of removing the oil and on the efficiency of decorticating such seeds as cotton seeds or ground nuts.

* Such works as *The Scientific Feeding of Animals* (Kellner), *Fatty Foods* (E. R. Bolton and C. Revis, chap. viii.), and the reports of investigations of various Agricultural Experimental Stations in the United Kingdom, America, and the Continent should be consulted for full details.

	Moisture.	*Oil.*	*Crude Proteins.*	*Digestible Carbo-hydrates.*	*Woody Fibre.*	*Ash.*
Linseed cake;						
English made (average)* ..	11·2	9·5	29·5	35·5	9·1	5·2
Meal (extracted)*	13·2	3·0	34·7	34·7	8·8	5·6
Cotton-seed cake:						
Undecorticated†	11·3	6·2	23·8	31·3	21·8	5·6
Decorticated†	8·7	7·9	40·3	26·0	10·1	7·0
Rape-seed cake:						
French cake*	8·1	9·3	36·4	29·3	7·9	9·0
Meal (extracted)*	10·2	2·9	40·2	33·6	8·4	4·7
Sesame cake:						
Typical sample†	8·2	8·6	38·7	25·2	5·2	14·1
Ground-nut cake:						
Undecorticated*	10·0	7·7	29·9	26·1	22·2	4·1
Decorticated†	10·7	5·8	45·1	30·5	3·8	4·1
Soya-bean cake:						
Cake†	10·9	6·3	44·7	27·0	5·4	5·7
Meal†	11·6	0·5	46·1	31·1	5·8	5·9
Coconut cake:						
English‡	9·9	8·0	23·0	44·2	9·2	5·7
English‡	8·5	8·3	24·5	39·8	12·8	6·1
Palm-kernel cake:						
Cake†	11·8	6·6	17·0	47·1	13·8	3·7
Cake (English made)§	12·0	5·5	18·5	50·0	10·0	4·0
Cake meal (extracted)‖	15·0	2·0	19·0	51·0	9·0	4·0

Generally speaking, a high ash content is due to imperfect removal of earth and sand from the seed; high fibre content to inefficient separation of shells or husks—shell, for example, in palm kernels, husk in the case of cotton seed and ground nuts. The presence of husk or shell naturally increases indigestible fibre at the expense of nutrient constituents.

DRYING OILS

LINSEED.

Linseed is derived from the flax plant, *Linum usitatissimum*, the source of flax (linen) fibre; when grown for the sake of fibre this plant does not produce much seed, and the enormous quantities of linseed used as oilseed are mainly the produce of plants cultivated specially for the seed alone, and which do not produce fibre of value for textile purposes. The possibility of devising a means of utilizing the straw of flax plants grown for seed is obviously one of great importance, and

* Analyses by Smetham, *Journ. Roy. Lanc. Agri. Soc.*, 1914.
† *Fatty Foods*, E. R. Bolton and C. Revis.
‡ *Bul. Impl. Inst.*, 1914, **12**, 576.
§ *Bull. Impl. Inst.*, 1914, **12**, 578 (average of factory analyses over three months).
‖ *Bull. Impl. Inst.*, 1914, **12**, 578 (average of factory analyses over three months; the moisture content is high).

one to which a good deal of attention has been given; at present, nearly all such straw is burned, though in the United States of America some of the straw is utilized—chiefly for the production of tow for upholstery purposes, and experiments have been made with a view to the production of paper pulp.

The world's average yearly yield of linseed for the years 1909-13 has been estimated* as some 2,700,000 tons, the following tables showing the areas cultivated and the production of seed during recent years in the most important countries producing this crop.

AVERAGE AREAS CULTIVATED ANNUALLY (IN ACRES).

	1919–1922.	1922.
Argentina	3,736,700	4,049,100
India	2,588,500	2,993,000
U.S.A.	1,419,000	1,308,000
Canada	904,950	565,500
Total	8,649,150	8,915,600

No figures are available for areas under linseed in Russia, formerly an important source of linseed.

ANNUAL PRODUCTION OF LINSEED (IN TONS).

	1919–1922.		1909–1913.
	Maximum.	*Minimum.*	*Annual Average.*
Argentina	1,261,744	806,811	777,908
India	434,000	235,000	496,760
U.S.A.	305,950	181,400	487,595
Canada	199,940	102,794	301,006
Total ..	2,201,634	1,326,005	2,063,269

ANNUAL AREA (ACRES) UNDER LINSEED.

	1922.	1921.	1920.	1919.	1913.
Argentina	4,049,100	3,892,000	3,483,000	3,521,800	4,396,900
India	2,993,000	2,269,000	3,103,000	1,989,000	4,124,900
U.S.A.	1,308,000	1,108,000	1,757,000	1,503,000	2,291,000
Canada	565,500	533,000	1,428,000	1,093,100	1,552,800
Russia	—	—	—	—	4,100,000
Total ..	8,915,600	7,802,000	9,771,000	8,106,900	12,365,600†

Consideration of the above figures shows that both the area and production of linseed have fluctuated during recent years to a fairly considerable extent. Owing to very wide variations in yield of seed per acre it is advisable to consider acreage rather than production for purposes of comparison in any particular year. At the end of last century Russia was the chief producer, but since then—owing

* *Oleaginous Products*, 1923, p. xii (International Institute of Agriculture, Rome).
† Omitting Russia.

to competition of other countries and changing conditions in Russian agriculture—linseed cultivation has declined, and although comprehensive statistics are not available it appears evident that production is now greatly reduced.

In Argentina the area under linseed has remained at a very high figure since 1909, varying from 3,233,700 acres in 1917 to 4,396,900 acres in 1913, and even during the War the area cultivated remained almost constant.

In the United States the largest area cultivated was 2,851,000 acres in 1912, but the largest area since the commencement of the War was that of 1917—viz., 1,984,000 acres; the home supplies are all absorbed locally and linseed is imported in large quantities.

In Canada the development of linseed cultivation was extremely rapid, rising from 16,200 acres only in 1889 to 2,021,900 acres in 1912, since which year the area has varied very considerably. The majority of Canada's linseed crop now goes to the United States, though previous to the War large quantities came to the United Kingdom; thus in 1913 Canada's contribution to the linseed imports of the United Kingdom amounted to some 256,000 tons.

In India, extension of cultivation occurred from 1900 to 1912, when the maximum area, 5,038,000 acres, was reached, and in which year over 520,000 tons of seed were exported. Since that date there has been a general tendency towards reduction. It should be noted that areas under crops in India often refer in part to areas under mixed crops.

Linseed is also cultivated to a greater or less extent in most European countries, but the production of seed is not considerable, especially where, as in Ireland, the crop is grown for fibre and generally harvested before the seed is ripe. Among the minor producers of linseed the most important in 1922 were:

Belgium	8,903 tons.	Czecho-Slovakia	9,426 tons.
France	5,572 ,,	Italy	10,800 ,,
Lithuania	27,795 ,,	Poland	49,866 ,,
Latvia	15,267 ,,	Japan	6,883 ,,
Rumania	4,841 ,,	Uruguay	14,763 ,,
Morocco	6,671 ,,		

A comparison of the production of linseed in the Empire is afforded by the table on p. 44 of approximate average yearly yields from 1909 to 1913, in the most important countries only, to which are added for comparison figures for 1922.*

It may be noted that the average yearly yields for "other countries" is, probably, on the low side, and that no account is taken of minor sources within the Empire, among which mention might be made of Australia (183 tons in 1922) and New Zealand (4,552 tons in 1922). Linseed, either for seed or fibre, has been grown experimentally or on a small scale in several parts of the Empire—*e.g.*, the Sudan, Natal, Rhodesia. In Kenya Colony considerable interest has been taken in the cultivation of flax for fibre, but it does not appear that seed is likely to be produced in quantity (*Bull. Impl. Inst.*, 1917, **15**, 374). It will be seen that India and Canada are the only important sources of linseed within the Empire, and that together these produce about 29 per cent. of the world's export supplies.

* *Oleaginous Products*, xiii.

PRODUCTION OF LINSEED (TONS).

	1909-1913 Yearly Average.	Percentage of Total.	1922.
British Empire:			
India	492,100	18·0	434,000
Canada	295,300	10·8	125,212
Total	787,400	28·8	559,212
Foreign countries:			
Argentina	777,500	28·4	1,157,000
Russia	590,500	21·6	—
United States	492,100	18·0	305,950
Other countries	88,600	3·2	—
Total	2,736,100	71·2	—

An idea of the relative importance of the largest consumers of linseed—*i.e.*, manufacturers of oil and cake—is evident from the following figures:*

LINSEED (TONS).

		1922.	1913.
Imports to United Kingdom from:			
Argentina	178,995	358,884	617,774
India	158,231		
Canada	327		
Other sources	21,331		
Shipments to the Continent from:			
Argentina	420,000	550,125†	1,226,800
India	130,125		
Production in U.S.A.		305,950	446,325
Imports to U.S.A. (include imports from Canada)		372,829	231,163 (1914)

It will be seen, therefore, that the actual quantity of linseed taken during 1922 by Great Britain, the Continent of Europe, and by the U.S.A. (including home production) amounted to some 1,588,000 tons, and it might be noted that the demand for linseed in the United States appears to be on the increase, and that in view of tariffs on imported linseed and oil the growing of linseed in the States seems likely to increase. With regard to the linseed requirements of the Empire it is of interest to note that Great Britain is the only large importer within the Empire.

The only other country within the Empire which imports an appreciable quantity of linseed is Australia, which requires some 40,000 tons yearly.‡ Small quantities are taken by South Africa—chiefly by Rhodesia—where the seed is used for cattle-feeding.

* *Review of Oil and Fat Markets*, Thornett and Fehr.
† Import to Germany, 103,155 tons; France, 137,984
‡ *Bull. Impl. Inst.*, 1917, **15**, 373.

Broadly the requirements of the United Kingdom amount to some 520,000 (the imports amounted to over 521,000 tons in 1919, and to nearly 359,000 tons in 1922) tons of seed a year, which might all be produced within the Empire.

In this connection it is of interest to quote the following statement from "Indian Trade in Oil Seeds,"* to the effect that—"The average contribution of linseed from India to the United Kingdom in the five years 1912-16 was over 41 per cent. of the total imports. It does not seem likely that the linseed-producing countries of the Empire will in the near future provide more than 50 or 60 per cent. (40 from India, 10 to 20 from Canada) of the requirements of the United Kingdom, assuming the latter to be about 520,000 tons per annum. Russia should be able to provide from 20,000 to 50,000 tons a year. The remainder will have to be obtained from Argentina, and in view of large British investments there it seems likely that considerable quantities will be obtained from Argentina."

Since the above was written Canada has practically ceased to send linseed to Great Britain, and supplies from Russia are at present quite insignificant.

India has shown in the past that the area there can be increased very considerably above that planted in the last few years, and has, indeed, in one year (1911) exported some 528,000 tons of seed.

The possibilities of future supply from Russia are still vague,† and perhaps this may act as an incentive to development of linseed cultivation within the Empire. Linseed and linseed oil have, however, been subject to wide—even extreme—fluctuations in value in the past;‡ and although the demand for linseed oil and cake is very large, over-production or a surplus supply of seed due to a "bumper" crop would probably cause a severe drop in the price of seed, with the inevitable result of loss to the producer or, at the best, a great reduction in anticipated profit..

Any proposals to develop the cultivation of linseed within the Empire must, therefore, be considered from every possible point, and would seem to show promise of success only in countries where either a good local demand for the seed exists or where the crop can be grown cheaply, so that a fair margin of profit may be anticipated to cover costs of freight or compensate for a possible drop in the value of the seed produced.

The price of linseed in London during 1922 varied from £18 9s. 9d. to £22 16s. 3d. per ton, the spot price on February 22, 1924, being £20 10s. per ton for La Plata seed.

Since 1909 the lowest price was about £12 10s. per ton.

In Buenos Aires linseed sold during 1922 at from 15·9 to 21·8 dollars per quintal (220·5 pounds).

It should be noted that the linseed market is a distinctly speculative one owing to the practice of selling in advance.

* *Bull. Impl. Inst.*, 1917, 15, 374.

† Since 1919 only small amounts of Russian linseed have appeared on the markets of Great Britain. In 1922 only 422 tons were obtained from Russia.

‡ As an example of this it may be noted that during 1909 linseed sold in London around £12 10s. per ton, and that during 1922 the price was from about £18 10s. to nearly £23 per ton. Linseed oil in 1909 sold at as low as 20s. 9d. per cwt.; in 1922 up to 44s. 8d. per cwt.

Linseed Oil.

Linseed oil is chiefly used in the manufacture of paints and varnishes—it is, in fact, the most used oil for these purposes—and in the manufacture of linoleum and floor-cloth; this fact must be kept in mind in considering figures for export of linseed oil, as very considerable amounts of oil are indirectly exported in these forms (though obviously no accurate estimate of the amounts of oil represented can be made). Speaking in round numbers the treatment of linseed results in the production of 35 per cent. of oil and 65 per cent. of cake.

Although India is so large a producer of linseed the quantity of oil produced there cannot be very large. A certain amount of oil of Indian manufacture is exported,* but it appears evident that this is not equal in quality to that of European manufacture,† and some oil is imported to India from Europe, although the quantities of oil as such do not in normal times amount to more than about 1,500 tons yearly.

Great Britain is the only large producer of linseed oil within the Empire and, assuming that the average of 520,000 tons of linseed are worked annually, the production of oil must amount to some 192,000 tons, of which the great majority is obviously employed in home manufactures.

Annual exports of linseed oil during 1909-13 only varied between 22,312 and 29,911 tons, but since 1920 have amounted to about 50,000 to 60,000 tons a year, the actual quantity for 1922 being 59,388 tons, valued at £2,352,101. It is quite evident that large amounts of linseed oil are exported indirectly in the form of paints, etc.

Imports of oil from 1909 to 1913 varied from 11,888 to 38,463 tons, and in the last few years the imports have fallen to almost insignificant figures; thus, only 4,064 tons were imported in 1922.

The price of linseed oil has been subject to very wide fluctuations even over the comparatively short period covered by the present century; in London it has been as low as 15s. per hundredweight (including barrels) in 1904; in 1913 the price was from 23s. to 27s. per hundredweight; and during 1922 has varied from about 38s. 6d. to 44s. 8d. per hundredweight (naked). The extraordinary prices fetched by the oil in 1919-20—up to 123s. per hundredweight—are noteworthy.

Recent prices (February, 1924) are as follows:

	Per Ton Net.
Hull (raw)	£47 (naked).
Liverpool (boiled)	£53 (barrels).
Liverpool (raw)	£51 ,,

* Exports of Linseed Oil from India.

	Quantity (Gallons).	*Value (£).*
1910–11	316,111	42,594
1911–12	249,075	49,966
1912–13	108,867	20,823

† *Bull. Impl. Inst.*, 1917, **15**, 378.

Linseed Cake.

The residue obtained in the manufacture of linseed oil from linseed in the form of cake where the oil is obtained by expression, or of meal* when the oil has been extracted by solvent, is very rich in protein and has a high nutrient value, and is, in fact, probably the most popular feeding cake (particularly for cattle) used in Great Britain.

The normal annual production of linseed cake in Great Britain must amount to about 338,000 tons, and the home consumption can be judged from the fact that imports of linseed cake largely exceed exports.

LINSEED CAKE, 1922.

	Imports.	*Exports.*
Tons	48,739	8,822
Value	£637,122	£113,989

A fair proportion of the imported cake is of Empire manufacture. 17,824 tons, valued at £233,844, were derived from the Empire as follows: India, 10,312 tons; Australia, 4,462 tons; Canada, 2,927 tons; and other British Possessions, 123 tons.

The price of linseed cake in the United Kingdom varied during 1922 from £12 7s. 6d. to £15 15s. per ton compared with about £7 12s. to £8 4s. in 1913. In February, 1924, London-made cake was about £12 15s. per ton ex mill.

TUNG OIL.

Tung oil (wood oil) has been known since very early times in China, where the oil is used for varnishing wood, for waterproofing paper and fabrics, and for caulking boats.

Tung oil has now become widely known in Europe and America, and is an increasingly important article of commerce. The oil is obtained from species of the genus *Aleurites*, all of which yield oils of economic importance, but which have various points of difference between them. The trees grow in Eastern Asia and Malaya, and owing to the peculiar economic conditions of China are little cultivated. All over China it is essential for the various communities to produce their own food-stuffs and to be largely self-supporting, chiefly because of difficulties of intercommunication, and the tung-oil tree can then only be grown on what is to be regarded as waste land, for neither tung oil itself or the cake left after extracting the oil can be used for food.

As a substitute for linseed oil in paints and varnishes difficulties were at first encountered owing to the film produced by the raw oil on drying being opaque and having a matt and sometimes a wrinkled surface, and to the fact that when heated alone the oil polymerizes to a solid jelly-like substance practically insoluble in oil or turpentine or other solvents, and therefore valueless for making varnish. These technical details have now been overcome by mixing a proportion of linseed

* Much of the linseed meal produced in this way is no doubt consumed by compound cake manufacturers.

oil or other drying oil or of resin with the tung oil before heating, and by careful control of temperature; at present increasingly large quantities of the oil are being absorbed by the paint and varnish industries, particularly in America.

Considerable confusion existed formerly as to the exact species of *Aleurites* yielding the different commercial kinds of tung oil, but it is now established* that *Aleurites Fordii* furnishes the bulk of the Hankow wood oil, that *Aleurites montana* is the chief source of Canton wood oil, and that Japanese wood oil is derived from *Aleurites cordata*. Of these the most widely distributed is *Aleurites Fordii*, the which species appears to be the hardiest and the most suitable for introduction to other countries. The oil obtained from *Aleurites cordata* differs in some important respects from Chinese wood oil, chiefly in the very much longer time it takes to polymerize, and Japanese wood oil cannot be supplied in fulfilment of a contract for Chinese wood oil.

The tung-oil tree does not usually attain very large dimensions, a full-grown tree of *Aleurites Fordii* generally reaches a height of about 25 feet and does not exceed about 30 feet; the fruits are easy to gather and are first borne four to five years after sowing the seed. They consist of an outer pulp, which soon rots away on keeping, and the three to five seeds are then removed.

In China the seeds are crushed, partially roasted, and steamed. The mass is then made into circular cakes about 18 inches in diameter and 4 inches thick, which are crushed in primitive wooden wedge presses. The kernels contain about 53 per cent. of oil and about 40 per cent. is extracted by the above method. The residue left in the presses is used as manure. Since the world demand for tung oil is increasing, and the supply cannot, under present economic conditions in China, be increased indefinitely, it becomes important to consider other sources of supply. There is no doubt that *Aleurites Fordii* is the most suitable species for cultivation in warm temperate climates, and that it might be grown most advantageously on waste land which cannot be otherwise utilized profitably. The tree flourishes on rocky hillsides and ground unsuitable for the more exacting crops, and there is little doubt that it would flourish successfully in large tracts in Australia, South Africa, Kenya, and India. Up to the present the only country which has devoted attention to the cultivation of tung-oil trees is the United States of America, where fair numbers of trees have been grown in the Southern States. In 1921 there were thirty-one plantations mostly consisting of 200 to 250 trees, but in one case in Florida 6,453 trees have been planted.†

A recent survey (1923) of the possibilities of Florida for tung-oil production shows the great interest that America is taking in producing her own supplies of this oil. It is estimated that 50,000 acres of land would supply this need, and in view of the very satisfactory results so far obtained it is probable that planting on a much more extensive scale will shortly take place.

Transportations of seed for planting from China can be successfully carried out if a few simple precautions are taken, and it is greatly to be hoped that tung-oil production will commend itself to the authorities in suitable parts of the Empire, as the demand for this oil is likely to continue to expand in the future.

* E. H. Wilson, *Bull. Impl. Inst.*, 1913, 11, 441.

† *Circular* 123, 1921, *Bureau Paint Manuf. Assoc., U.S.A.*

Trade in Tung Oil.

For the following particulars we are indebted to Messrs. Dexters', Ltd., Market Report.

It is stated that the quantity of tung oil marketed in Hankow varies roughly between 60,000 to 70,000 tons a year. Much of this, however, is not of good quality, and the amount exported from China is shown below, together with the chief destinations.

	1918 (*Tons*).	1919 (*Tons*).	1920 (*Tons*).
Total exports from China	29,098	36,513	32,184
To U.S.A.	14,311	18,462	22,616
,, United Kingdom	1,765	2,766	1,679
,, Hong Kong	7,625	5,101	4,636
,, Canada	3,438	7,684	325
,, Japan	1,025	1,018	544
,, Germany	—	—	965

It is thus evident that the U.S.A. take a very large proportion of the Chinese exports. In addition to the total of 22,616 tons imported to the U.S.A. from China in 1920 a further 5,443 tons was derived from other countries, mostly shipped from Hong Kong (to which port increasing amounts of tung oil have of late years been sent).

Imports into the U.S.A. in 1922 amounted to 36,247 tons, which is a big increase over the figures shown above. To supply the U.S.A. with their estimated requirements in oil for the year 1924, and also to allow for the average requirements of other countries, it is estimated that China would have to export something like five-sevenths of her production. Under present conditions this is practically impossible, and even under favourable conditions it is not likely that an increase in Chinese exports could satisfy the demand for some years at least.

It is therefore evident that the question of introducing cultivation of the tung-oil tree in the parts of the Empire with suitable climatic conditions referred to above is one deserving of immediate attention. The price of Hankow wood oil was £95 per ton in February, 1924, in London.

PERILLA OIL.

This drying oil is produced from the seeds of *Perilla ocymoides*, which is grown chiefly in Japan and Manchuria, but is also cultivated in Northern India. It is of commercial importance in Japan, where the oil is used for waterproofing and in lacquer; the production of seed in Japan has been stated* to amount to about 325,000 bushels, 1 bushel yielding about 1 gallon of oil. Although considerable quantities of oil are produced, the oil does not appear in any quantity on the European markets.

This plant is certainly suitable for cultivation in many countries; experiments

* *Journ. Soc. Chem. Ind.*, 1910, 29, 1320.

in Ohio in the United States of America gave rather unsatisfactory results in 1911, only about 400 pounds of seed per acre being obtained. It grows in the tropical and temperate regions of the Himalaya from Kashmir to Bhotan from 1,000 to 10,000 feet elevation, but the seed does not appear to be exported.

The possibilities of utilizing perilla oil in Europe for paints and varnishes have been investigated by several workers, and it has been stated frequently that it is inferior to linseed oil; this adverse opinion is, however, not endorsed by other workers,* *e.g.*, Morrell†, who considers the oil to be excellent for paints and varnishes. It now seems certain that the earlier adverse opinions are due to unsuitable methods of treatment and the use of unsuitable driers, and that perilla oil would form a valuable addition to the rather limited range of commercial drying oils, though its comparatively high price limits its use to certain special purposes.

In 1918 supplies of Japanese seed were sent to India, East Africa, South Africa, and Cyprus for trial. In Cyprus on an experimental scale a crop was obtained in 1919 equivalent to about 450 pounds of seed per acre—a much lower yield than is usual in Japan—but the seed was of normal character.‡ It appears that trials in other countries are still in progress, and no definite results are yet available.

Poppy Seed.

The poppy, *Papaver somniferum* (Natural Order Papaveraceæ), is chiefly cultivated as the source of opium, when the seeds form a secondary crop, although in some European countries, particularly France, it is grown as a source of seed alone. There are two main varieties of the poppy, black and white. As a rule the black or blue variety, yielding "huile d'œillette," is grown in Europe, while the white varieties are of foreign origin and give what is known as "huile de pavot."

The largest producer of poppy seed is India, and Russia probably comes next, but no separate returns for the Russian production are available; the quantities, however, are probably small. The poppy is also cultivated in Macedonia, Asiatic Turkey, Persia, and China. It is probable that the decisions of the League of Nations to restrict the opium output will have a considerable influence in the future on the acreage under this crop.

It is impossible to form an estimate of the area in China under poppy cultivation. The efforts of the Chinese Government to stamp out opium traffic caused a very great diminution in acreage, but it appears that owing to the recent internal disturbances in that country less vigilance is being exercised, and since there is always a demand for opium, the poppy is again being cultivated. It is not probable that there has been any large surplus of seed for export at any time.

Of late years a great change has come about in the areas under cultivation in India due to the Chinese Government's attempts to stamp out the opium trade.

* *Chem. Rev. Fett. Harz. Ind.*, 1912, **19**, 59.
† *Varnishes and their Components.*
‡ *Bull. Impl. Inst.*, 1920, **18**, 479.

The effect of China's agreements of 1909 and 1911 with the Indian Government has been to decrease the Indian exports of seed from 42,458 tons in 1909 to 6,622 tons in 1921, and it is obvious from the following statistics that production has fallen universally. In 1903-04 the estimated area under poppy in India was 769,000 acres, while in 1915-16 it had diminished to 181,000 acres.

EXPORTS OF POPPY SEED (TONS).

	1909–1913.		1921.
	Maximum.	*Minimum.*	
Belgium	8,981	2,165	..
Hungary	185	45	928
Netherlands	—	—	2,282
India	42,458	17,039	6,622

France and Germany have been the largest importers and still maintain that position. France obtains most of her supplies from India, while Germany has probably taken all the Salonica exports and those from Asiatic Turkey and Persia.

IMPORTS OF POPPY SEED (TONS).

	1909–1913.		1921.
	Maximum.	*Minimum.*	
Belgium	12,497	7,611	—*
France	25,391	8,813	4,011
Germany†	26,291	16,144	1,118

The imports into the United Kingdom are almost negligible. In 1914-15 some 84 tons, and in 1915-16, 143 tons, of seed were imported from India, and in view of the general decline in cultivation it is not likely that these figures will be much exceeded in future.

It is, however, probable that a definite amount of poppy seed will always be available, for opium is a world necessity, and this is obtained from the capsules containing the seed, but not from the seeds themselves.

Poppy-seed oil is a drying oil and finds its chief use in the manufacture of paints, although it is used to a certain extent for edible purposes.

Poppy-seed cake is used to a certain extent for feeding stock. It is high in nutritive value, but is said to have poor keeping qualities.

HEMP SEED.

Hemp seed is obtained from the hemp plant, *Cannabis sativa*, which grows wild in Central Asia and is cultivated in temperate and tropical countries of both hemispheres. The plant is mainly of importance for the production of fibre, and the well-known Eastern narcotic "bhang," "ganja," or "charas," is obtained

* Included in "other unspecified oleaginous products."
† Including sunflower seed.

from the leaves and flowers. In temperate climates it is chiefly grown for fibre and sometimes for seed, but in the tropics the drug is the important product.

Since the seed is often produced as a by-product from fibre cultivation the quality is apt to be variable, but in some places—for example, the U.S.A.—the plants are specially grown for seed, which is gathered by cutting down the plants as soon as they reach maturity, when the seeds drop readily. Hemp seed is very prone to heat, and for this reason storing in bulk is to be avoided.

As far as the production of hemp seed is concerned the areas under cultivation are misleading as they include crops grown for fibre. Russia is, however, by far the largest producer, and the latest available figures show that in 1920 some 1,209,290 acres were under hemp. Italy comes next and then Poland. Cultivation in Hungary appears to be on the decline.

IMPORTS OF HEMP SEED.

	1909–1913.		1921.
	Maximum.	*Minimum.*	
Austria	11,498	2,316	—
France	13,407	6,941	2,762
Germany	9,697	5,596	942
Netherlands	3,276	2,033	1,374
Japan			4,043

EXPORTS OF HEMP SEED.

Austria	3,082	1,236	—
Germany	5,820	2,063	10
Hungary	2,832	233	—
Rumania	3,845	814	—
Russia	21,319	8,733	—
Chile	186	7	1,459

It is unfortunate that so few figures are available for 1921, but it seems certain that the trade in seed and oil has diminished. Japan appears to be making more use of this seed, and is now importing appreciable quantities, and Chile has of late years increased her exports. As far as Great Britain and the Colonies are concerned the trade is almost negligible.

The seeds yield about 30 per cent. of greenish-yellow drying oil, which finds a use as a paint oil, and on the Continent for soft soaps. The cake is used to a certain extent as a cattle food, but it contains a rather high proportion of fibre. (See *Fatty Foods*, Bolton and Revis, p. 280.)

SEMI-DRYING OILS

COTTON SEED.

Cotton seed is produced by the cotton plant (*Gossypium* species), of which many varieties are cultivated in all the warmer parts of the world for the sake of the fibre.

Prior to about 1870 the enormous quantities of cotton seed produced in such

countries as the United States of America were not used as a source of oil; limited quantities of seed were employed as manure and as food for cattle and other animals, but the bulk of the seed was wasted, and in fact disposal of seed was a troublesome problem. The realization that the seed afforded a source of valuable oil, however, has led to the utilization of the bulk of the world's supplies of this by-product of the vast cotton-growing industry.

The chief centres of the world's cotton-growing industry are the United States of America, India, and Egypt, while Russia was formerly an important producer, though the area under cotton is now considerably reduced. The enormous and ever-increasing demand for cotton in the world's markets has led to increased growing of cotton in many countries during recent years; for example, the area in Brazil increased from 500,000 acres in 1915-16 to 1,500,000 acres in 1922-23, and in Korea from 176,000 acres in 1913-14 to 356,000 acres in 1922-23. The increase in cotton-growing in the British Empire has been very marked in such countries as Uganda, Nyasaland, Nigeria, and Australia. The results in these countries are due to the praiseworthy efforts of the various Governments concerned, and of the British Cotton-Growing Association.

Some idea of the enormous extent of cotton-growing and of the quantities of cotton seed produced is evident from the following table showing areas of cultivation and production of seed in the principal countries:

YEARLY AVERAGE.

	1909-10 *to* 1913-14.		1922-23.	
	Area (Acres).	*Seed (Tons).*	*Area (Acres).*	*Seed (Tons).*
United States	33,153,000	5,186,000	33,734,000	3,950,000
India	22,492,000	1,782,000	19,845,000	1,714,000
Egypt	1,743,000	600,000	1,868,000	433,000
Russia	1,137,000	260,000	238,000*	24,000*
Total	58,525,000	7,828,000	55,685,000	6,121 000

The area under cotton in these countries is at present about the same as before the War, but the production of seed has decreased considerably owing to smaller yields per acre, particularly in the United States and Egypt, and so far the increase in cotton-growing in other countries does not appear to have compensated for the smaller production in the chief cotton-growing countries.

With regard to exportable supplies of seed it is of interest to note that these are mainly obtained from Egypt and India together with China and Brazil and various other countries, as practically the whole of the cotton seed produced in the United States is converted locally into oil and cake.

Cotton-seed oil and cake are manufactured in very large quantities in the United Kingdom and on the Continent of Europe; during the War practically all the available supplies were worked up in Great Britain, and since the War Continental countries, such as France and Germany, which imported considerable amounts of seed before the War, have commenced again to import

* 1921-22.

considerable quantities of seed, though they have not yet nearly attained the important position which they held before the War.

Although the United States at present holds first place as producer of cotton seed, oil, and cake, these products are of enormous importance to the Empire, particularly India and Egypt, and the increasing importance of cotton-growing throughout the Empire will undoubtedly lead to the production of increasing amounts of cotton seed in ensuing years.

The cotton seed obtained from the various types of cotton grown varies considerably in appearance and character; the majority of American cotton seed is of the American Upland type—the seeds of which are of fair size and covered with a coating of closely adherent short fibre or "fuzz." Long staple Sea Island cotton is also grown in some of the Southern states; this has large black smooth seed. Egyptian cotton seed is of fair size and chiefly smooth with only a small tuft of "fuzz," while Indian cotton seed is mostly small and covered with "fuzz."

The prices of cotton seed in the United Kingdom in 1913 and 1922 and at present are shown below:

EGYPTIAN COTTON-SEED PRICES.

	1913. £ s. d.	1922. £ s. d.	1923. £ s. d.
Maximum	9 11 3	12 15 0	10 5 0
Minimum	8 12 8	10 0 0	12 11 3
Average ..	9 2 0	11 11 5	11 7 0

PRICES IN HULL ON FEBRUARY 22, 1924 (PER TON).

	£ s. d.
Egyptian black	13 16 3
,, Sakellarides	12 2 6
Bombay (February to March)	10 17 6

Egyptian cotton seed of the "Sakellarides" variety sold in Alexandria during 1922 at from 95·15 to 125 piastres per ardeb (267·45 pounds).

Cotton-Seed Oil.

In working cotton seed for oil and cake the closely adherent fibrous coat is generally removed by special machinery, the short fibre "linters" being used for such purposes as paper-making. In many cases the tough woody shell or hull of the seed is also removed in decorticating machines. The removal of "linters" is advantageous, as their inclusion would lower the yield of oil obtainable, and because they are indigestible and lower the value of the cake for feeding purposes. Removal of the woody hulls is also advantageous, as oil of better colour and quality is furnished by the decorticated seed (kernels), and also because the hulls are hard and indigestible and detract from the feeding value of the cake.

Crude cotton oil varies a good deal according to the kind of seed it is derived from, and its character also depends on whether it is made from delinted, whole, or decorticated seed.

Generally speaking, oil from decorticated seed is superior to that from whole seed; American cotton oil is of lighter colour than and somewhat superior to oil from Egyptian seed, while oil from Indian seed is usually very dark coloured and distinctly inferior to American or Egyptian cotton-seed oil. The superiority of American cotton-seed oil is probably in part due to the fact that it is worked up in the country where the seed is grown, while Egyptian and Indian seed imported to Europe has had to withstand various adverse conditions over a long period during transport. All crude cotton oil is distinctly dark coloured—varying from red-brown to almost black—and possesses a curious rather distinctive odour.

Cotton-seed oil is refined in enormous quantities for edible use in America and in Europe; the processes employed consist of neutralization of free fatty acids by caustic soda (by which process the dark colouring matter is precipitated and removed with the soap-stock) followed by bleaching and deodorization.

Edible refined cotton-seed oil is used in the manufacture of margarine, as a salad oil, and various other cooking oils. "Demargarinated" oil (see p. 27) is also used as salad oil and in margarine, while large quantities of cotton oil are hardened and used—particularly in America—in "compounds" of the vegetable-lard type, and also for other purposes. Apart from its use for edible purposes cotton oil is largely used in soap manufacture. The "soap-stock" (see above), when of good quality, may be used direct in soap manufacture; the lower grades of soap-stock are generally acidified and converted into cotton-acid-oil ("black grease") for the production of fatty acids (by "splitting" and distillation).

In common with other vegetable oils the price of cotton-seed oil has increased to a fair extent since the War, the prices in Hull and in New York are compared below.

COTTON-SEED OIL.

	1913.	1922.	1923.
Hull: Refined oil (naked), per cwt. . .	26s. 0d. to 34s. 9d.	36s. 6d. to 48s. 3d	38s. 8d. to 44s. 9d.
New York: Prime summer yellow oil (cents per lb.)	5·83 to 9·58	8·55 to 11·7	7·45 to 13·55
New York: Prime summer yellow oil (average)	7·19	10·18	10·40

Prices of oil in February, 1924, are as follows:

	Per Ton Net (Naked).
Hull, crude	£43 10s. to £44 15s.
„ refined soap oil	£46 10s.
„ refined edible	£49
Liverpool, refined edible	£52

Cotton-Seed Cake.

Both decorticated and undecorticated cotton-seed cake are used in enormous quantities all over the world for feeding cattle and other farm animals, and are, in fact, among the most popular of commercial oil-cakes. For many years cotton-seed cake has been second only to linseed cake in popularity in the United Kingdom; in fact, prior to the War large quantities of cake manufactured from Egyptian seed were imported to the United Kingdom from Germany, where the cake did not meet with favour. In recent years other oilseed cakes—*e.g.*, soya bean, coconut, and palm-kernel cakes, have been produced in increasing quantities and have gradually found favour, as the somewhat conservative attitude of farmers towards new and untried feeding stuffs has been gradually overcome as the result of many feeding trials by various agricultural research institutions.

The prices of cotton-seed cakes in the United Kingdom in 1913, 1922, and at the present time are as follows:

Cake.	1913 (*per Ton*).							1922 (*per Ton*).						
	£	s.	d.		£	s.	d.	£	s.	d.		£	s.	d.
Hull: Bombay	3	7	6	to	5	10	0	7	0	0	to	8	15	0
„ Egyptian ..	4	15	0	„	6	0	0	7	15	0	„	10	5	0
London	5	6	0	„	5	18	6	7	7	6	„	9	6	3

Egyptian cotton-seed cake was selling at about £7 6s. 6d. per ton in February, 1924.

RAPE AND MUSTARD SEED.

The term "rape seed" is used rather loosely and is usually taken to include seeds of the various types of *Brassica campestris*, and very often includes mustard seed. Statistics sometimes relate to pure genuine rape, but often to a mixture of seeds, so that it is not possible to consider them separately. All these plants belong to the Natural Order Cruciferæ, and have large succulent leaves with small white or yellow flowers. They grow to a height of 18 inches to 4 feet, and the seeds are found in black pods about 2 inches long. The seeds are spherical and very small—from 6,000 to 40,000 weighing an ounce, and they vary in colour from white to dark brownish red.

Rape is extensively grown in England and elsewhere for fodder and is chiefly fed to lambs and sheep.

In considering the areas under rape seed it is unfortunate that detailed statistics for China are not available, as there is no doubt it is one of the largest producing countries. India supplies about four-fifths of the rest of the world's production, and Japan, Rumania, and Russia most of the remainder. The area under rape and mustard in India was in 1909, 6,028,500 acres, and in 1922, 6,120,000 acres; the highest recorded area in recent years is that of 1917-18, viz., 7,126,000 acres. A decrease was noted in 1919-21, but the pre-war level has again been reached. On the whole production in Europe is diminishing and has been doing so over a long period. An increase in acreage occurred in some countries during the War, notably in Germany, but has not been maintained.

The requirements of the European countries in rape and mustard seed have also diminished, and the only country in the world with an increasing demand appears to be Japan. The demand is not, however, sufficient to compensate for the decreased requirements of other countries.

Rape seed imported into this country is practically all used for home consumption.

IMPORTS OF RAPE AND MUSTARD SEED (TONS).

	1909–1913.		1921.	1922.
	Maximum.	*Minimum.*		
Austria	30,680	19,509		—
Belgium*	144,817	83,678	38,020	—
France	84,433	53,226	5,564	3,227
Germany	191,665	130,794	34,729	123,358†
Great Britain and Ireland ..	49,317	25,944	28,077	33,410‡
Italy	10,057	639	8,661	—
Netherlands	68,333	31,941	15,008	25,319
U.S.A.	5,678	4,073	3,377	—
Japan	27,301	2,034	68,126	

EXPORTS OF RAPE AND MUSTARD SEED (TONS).

Belgium	98,776	50,317	29,231	—
Netherlands	22,670	7,670	5,267	1,441
Rumania	81,672	31,292	—	—
Russia	58,994	7,505	—	—
China	47,955	13,267	67,711	—
India	390,205	206,656	56,724	133,697
Nepal	—	—	20,047	—

Hull spot prices of rape seed, February 22, 1924: Toria, £20 10s.; Ferozepore, £20 10s.

Rape Oil.

The oil obtained from the seed, either by extraction with solvents or by expression, is rather dark coloured, but can be refined to a pale yellow. Rape oil is one of the few vegetable oils still used extensively for lubricating purposes. This is owing to its high viscosity, and it is, in fact, even more extensively used for the purpose than castor oil. A good deal of the rape oil used for lubrication is "blown" oil—that is, oil thickened by blowing air through the heated oil. It is also used for soap, but is not very suitable owing to the high proportion of unsaponifiable matter which it contains. As a burning oil rape or colza oil has been largely superseded by petroleum oils.

Rape oil has long been used as an edible oil in India, and during the War the refined oil was used by many European countries in margarine and fat compounds.

Exports of rape oil are not very large, indicating that the large importers of the seed use most of the manufactured oil for home consumption. Amongst

* Chiefly transit trade to Germany. † Metric tons (2,205 lbs.).
‡ 32,630 tons from India.

European countries Great Britain and Ireland have been the largest importers, but latterly imports have diminished considerably, and the United States is the only country whose imports reach thousands of tons.

IMPORTS OF RAPE OIL (TONS).

	1909-1913. Maximum.	1909-1913. Minimum.	1921.	1922.
Belgium	2,284	1,041	*	—
Great Britain and Ireland	13,489	7,599	500	1,251
Netherlands	2,158	414	501	840†
U.S.A.	4,922	2,360	3,251	4,848

Towards the end of the War the Netherlands were importing more rape oil than any other country, the figures in 1917 reaching 11,659 tons, although it fell in 1918 to 4,491, and the U.S.A. took first place with 10,490 tons. The exports for these periods, however, were negligible for both countries.

It may be noted that the Indian exports of oil go almost entirely to British countries, Mauritius and Natal taking the largest proportion.

EXPORTS OF RAPE OIL (TONS).

	1909-1913. (Maximum).	1909-1913. (Minimum).	1921.	1922.
France	2,559	1,757	1,572	404
Germany	8,808	2,227	310	—
Great Britain and Ireland	6,362	5,079	2,719	4,944
Netherlands	3,426	1,058	1,254	2,136
India	1,666	1,017	1,368	—
Japan‡	5,207	803	1,522	—

Rape-Seed Cake.

Rape-seed cake is used as a feeding stuff; but, at any rate in the United Kingdom, it is less used than formerly. This may be due to the fact that rape-seed cake—particularly Indian cake—has the reputation of being adulterated and is liable to contain mustard seed, which has an injurious effect on cattle owing to the presence of the ethereal mustard oil. Rape-seed cake is probably a constituent of a good many of the compound cakes, and is said to find more favour on the Continent than here. The chief outlet in the United Kingdom for the cake and meal is, however, as a manure, and it is largely used for wheat and barley and also for potatoes, root crops, and hops.

The imports of rape-seed cake to the United Kingdom are shown below; the consumption of rape-seed cake is considerable, as exports and re-exports are insignificant.

* Included in "other unspecified oils."
† Excluding oil in transit.
‡ Exports of oil rose to a maximum in 1916 (13,053 tons).

IMPORTS OF RAPE-SEED CAKE TO UNITED KINGDOM (TONS).

	1913.	1920.	1921.	1922.
From Russia	25,839	—	—	—
„ other foreign countries	3,020	9,537	12,180	10,661
„ British Possessions	23	450	—	7
Total	28,882	9,987	12,180	10,668

SOYA BEANS.

The soya bean, *Soya hispida*, is a leguminous plant indigenous to China, Manchuria, Korea, Japan, and Indo-China. Besides bearing pods containing the oleaginous seeds, the plant is much used for forage purposes, while the hay is relished by all animals.

The bean has been cultivated in China since very early times, and it is known to have been used 4,700 years ago. In addition to being a valuable source of oil, the beans have for a long time been used in many different food preparations, among which may be mentioned Japanese soy sauce and " tofu," a vegetable cheese which is one of the staple articles of diet in Japan. The oil is obtained from the bean either by pressing or extraction.

The oil content of the beans is liable to vary within fairly wide limits; commercial supplies of the beans generally contain 16 to 19 per cent. of oil, though samples have occasionally been found to contain 20 per cent. or even more. The yield of oil obtained by pressing depends, of course, on the efficiency and the length of time of pressing; it usually amounts to about 12 per cent. By extraction with solvents the majority of the oil may be removed, leaving 2 per cent. or less in the meal.

Largely owing to its many economic uses, and the fact that the plant withstands drought, slight frost, and also excessive moisture well, efforts have been made to introduce it in India and many of our Colonies, and it should be remembered that, like all leguminous crops, it enriches the soil in nitrogen, and is valuable as a " green manure."

Experimental batches of seed were sent as early as 1909 to many of the colonies; but it does not appear very likely that any of them will, at least for some time, be able to establish any considerable export trade, as in most cases a local demand springs up, leaving nothing over for export.

In India cultivation has hardly yet passed the experimental stage, and is also being tried in Burma. Attempts have been made to grow the crop in England; during 1909-11 experiments with seed imported from Manchuria and Japan were made, but only in a few cases was seed produced by the plants. Probably in England the chief use of the plant would be as a forage crop, and in the U.S.A. it is largely used for this purpose.

The introduction of soya beans into U.S.A. has led to the establishment of an increasingly important industry. Imports of beans, oil, and cake to that country have increased, as well as the cultivation of the bean. Between 1909 and 1921 the area in the United States of America under soya beans *cultivated*

as an oilseed crop increased from about 1,600 to 186,000 acres. The total area under soya is about five times as much, but some seven and a half thousand acres are used for pasturage, forage, and ensilage only and not for seed.

The first shipment of soya beans to the United Kingdom arrived in 1908 at Hull, and it is in this port that the United Kingdom trade in soya beans is concentrated. Its introduction was due, at least in part, to the Russo-Japanese War, when the occupation of Northern Manchuria by Russian troops created a large demand for food, and considerable agricultural expansion took place. On withdrawal of the troops it became necessary to find a foreign market for the surplus crop, and it went first to Japan. Later, owing to depression in Japan, it began to be exported on a large scale to Europe.

EXPORTS OF SOYA BEANS (TONS).

	1909–1913.		1921.
	Maximum.	*Minimum.*	
From China	614,276	656,781	682,041
,, Japan		—	2,105
,, Korea*	88,135	102,108	225,417

The great increase in Korean production is noteworthy; the total crop of seed for 1920 being about 600,000 tons.

It is impossible to obtain any idea of the total acreage under soya beans, since no figures are available for China, but it is evident that both production and consumption have increased of late years. It may also be remarked that, on the whole, imports of beans into Europe are diminishing, but in Asiatic countries they are on the increase. It must also be taken into account that production is likely to increase from the attempts which have been made and are still progressing to introduce it to countries with suitable climates—for example, Natal, Gambia, and India.

IMPORTS OF SOYA BEANS (TONS).

	1909–1913.		1921.	1922.
	Maximum.	*Minimum.*		
Denmark	47,209		42,361	
Great Britain and Ireland ..	421,531	76,452	61,425	59,357†
Netherlands‡	42,373	26,002	2,039	5,022
Germany				86,407
Dutch East Indies§		52,596	82,633	—
Formosa	5,697	718	10,421‖	—
Japan	105,143	213,960	173,176	—

Soya beans from Manchuria were quoted at £13 15s. per ton (afloat) in Hull in February, 1924.

* Figures for 1912 and 1913 not available.
† Valued at £753,934.
‡ No figures available for 1909 and 1910.
§ No figures available before 1913.
‖ 1920.

Soya-Bean Oil.

Undoubtedly China is the largest exporter of soya-bean oil, but it is a little doubtful exactly what figures are included in her exports. Probably the Manchurian and Korean exports are taken together with Chinese, and owing to the enormous increase of late years in Korean production of beans the figures given may be considerably influenced thereby.

The ratio of proportion of oil produced to beans is low in comparison with most oil seeds owing to the fact that the yield of oil is only some 10 per cent. of the beans.

Soya-bean oil came on the market at a time when a substitute for cotton oil was badly needed by the soap trade, and first came into prominence in this connection. Later it was refined and is now largely used for edible purposes, including margarine.

Amongst European countries Germany and the Netherlands are the largest importers of oil, with the United Kingdom second. Since the United Kingdom is the largest European importer of seeds, and exports both of seed and oil are comparatively small, it is evident that the bulk of the oil manufactured and imported is consumed at home. Large quantities of soya-bean oil are now shipped from the East in tank steamers, and it may be mentioned that a considerable import trade in hydrogenated soya-bean oil has latterly developed.

SOYA-BEAN OIL IMPORTS (TONS).

	1921.	1922.
Great Britain and Ireland	16,473	20,357*
Netherlands	32,667	24,757
Sweden	2,958	—
Germany	—	41,475
U.S.A.	7,715	7,721†

SOYA-BEAN OIL EXPORTS (TONS).

Denmark	5,862	—
Great Britain and Ireland	10,377‡	8,289
Netherlands	20,173§	—
U.S.A.	1,096‖	—
China	68,327	—
Japan	1,231	—

Soya-Bean Cake.

Soya-bean cake is a valuable feeding stuff. It is rich in albuminoids, and it must be regarded as a concentrated food when fed to cattle and mixed with such substances as cotton cake, maize, barley meal, and American flour. From

* Valued at £735,808.

† Imports of oil to U.S.A. reached a maximum in 1918 of 149,983 tons, and have steadily diminished since.

‡ Including 490 tons re-exports. § Highest recorded.

‖ Including 228 tons re-exports.

time to time there have been reports that soya meal has proved poisonous to pigs and cattle, but it seems probable that this has been chiefly due to feeding it in too large proportions.

SUNFLOWER SEED.

The sunflower (*Helianthus annuus*) is an annual plant belonging to the Natural Order Compositæ. The seeds contain about 22 to 25 per cent. of oil, and are a valuable source of oil and feeding cake. They are also used for food for poultry, while in some countries, particularly in Russia, large quantities of seed are grown for human consumption.

Although the sunflower is widely distributed and is to be found in practically all countries, it is only cultivated on a commercial scale in a few, and of these Russia is by far the most important. Hungary and China also grow a certain quantity, and of late years serious efforts have been made to bring the cultivation to a commercial scale in South Africa, and particularly in Rhodesia. Experimental crops have been grown with good results in various parts of Australia and New Zealand and in several of the British Colonies, while consignments of seed from India have been imported to the United Kingdom recently.

The climate of Great Britain is quite suitable for sunflower cultivation; the crop is exceedingly easy to grow and produces seed abundantly. In spite of this very little is grown in this country, probably owing to the fact that the value of the crop is not recognized.

Sunflower does well on most kinds of soils which are not too heavy, and after a crop which has required heavy manuring. The seed-heads are harvested before the seeds are quite ripe, dried, and the seeds freed either by holding the heads against a revolving cylinder studded with spikes, or by special machinery. The seeds should then be dried to prevent fermentation on storage.

The value of the sunflower crop does not lie entirely in the seeds, for the stems and leaves may be used as fodder or converted into a silage which compares favourably with maize silage (*Journ. Agric. Research*, 1919, **18**, 325). Further, the sunflower plant is particularly rich in potash, and after harvesting the seeds the plants may be burnt. An acre of land is said to produce 2,600 to 4,000 pounds of stalks, equivalent to some 160 pounds of ash, yielding 40 to 53 pounds of potash (*Bull. Impl. Inst.*, 1916, **14**, 93). There were numerous potash factories in the Caucasus, which exported, in 1913, 6,843 tons (excluding the amount kept by Russia, which is some quarter of the whole).

The importance of the crop in Russia is shown by the fact that in 1920 the total area under sunflower in Russia (chiefly South Russia) was put at 1,865,889 acres. This figure appears to denote a certain decrease in cultivation, but up-to-date and reliable information from Russia is difficult to obtain. Exports of seed from Russia (including small quantities of poppy seed) reached in 1913, 58,589 tons. Imports of seed to the United Kingdom were in 1920, 857 tons, in 1921, 1,465 tons, and in 1922, 2,187 tons.

Sunflower Oil.

The oil is a useful edible oil, but has been more used for this purpose on the Continent than in the United Kingdom. Inferior grades of oil find their way to soap-makers, and in some countries have been used for burning, while in Russia and Germany sunflower oil is said to be used for varnish-making. Its drying properties are, however, inferior to those of linseed oil. A great deal of oil is made in South Russia, but the local consumption is on a large scale. Thus, although 178,000 tons of oil were produced in 1913, the exports only amounted to 3,918 tons.

Sunflower Cake.

The cake left after the oil is expressed forms a valuable cattle food, and large quantities are exported from South Russia, chiefly to Denmark, but also to France, Sweden, and Norway. The undecorticated cake is naturally less valuable than the decorticated, and contains a high percentage of crude fibre. Up to the present sunflower cake has not been of interest to farmers in this country, although it probably enters into the composition of some of the compound cakes.

SAFFLOWER SEED.

The safflower plant, *Carthamus tinctorius*, belongs to the same Natural Order as the sunflower, and produces seeds which are similar to, but smaller than, sunflower seeds, and yield an oil of very similar composition. The plant is grown in India (where it was formerly largely used for the dye produced from the flowers) and also in Egypt and the Caucasus.

Owing to its superior ability to withstand certain diseases to which the sunflower is liable, substitution of sunflower by safflower has been suggested. The seeds possess a very hard husk, and it is therefore difficult to press out the oil, and decorticating is advisable. The seeds contain about 30 per cent. of oil, but if pressed without decortication yield less than 20 per cent. on pressing.

The cultivation of the crop is receiving attention in India, especially by the Agricultural Department of Bombay, and it is possible that considerable shipments will reach this country in the near future. It is estimated that some 15,000 to 20,000 tons of safflower oil are annually produced in India, and at present practically the whole of this amount is consumed in the country.

NIGER SEED.

Niger seed is obtained from the plant *Guizotia abyssinica* Cass. (Natural Order Compositæ), which is grown fairly generally in East Africa for local use, and also to a larger extent in India. The seeds are similar in shape to sunflower seeds, but very much smaller (about 4 millimetres long), quite black, and contain 40 to 50 per cent. of a pale yellow oil. The seed imported to Europe is practically all of Indian origin, and it is crushed in Hull and Marseilles.

It is not very likely that this plant will ever become a very important oilseed crop, as conditions of cultivation are much the same as for sesame seed, which

is more valuable. The oil is used to a considerable extent in India for cooking, and for lighting, but the export trade is small and cultivation is not on the increase, although there is no difficulty in disposing of seed imported to Europe. The cake left after expression of the oil is of approximately the same value as sunflower cake, and has been used from time to time by Essex farmers with satisfactory results.*

The exports of niger seed from India are now insignificant; before the War fair quantities were exported, for example:

	Tons.		Tons.
1911–12	10,105	1920–21	55
1913–14	4,107	1921–22	354

NON-DRYING OILS

Olive Oil.

This oil is prepared from the fruits of the olive tree, *Olea europea sativa* Linn., and cultivation of the olive tree is chiefly in the countries bordering the Mediterranean—*i.e.*, in Spain, France, Italy, Greece, and Northern Africa. The industry is an exceedingly old one, and is known to have been practised in Italy before 600 B.C. Attempts have been made to introduce olive trees in India, South America, South Africa, Australia, and elsewhere.

The olive is grown fairly extensively in California, but the oil industry in that country has not yet assumed large dimensions.

Cultivation in South America is promising, and figures of production in Chile are available.

Cultivation of the olive tree has been found quite possible in South Australia, where the rainfall averages between 17 to 28 inches, but the commercial growing of the tree has not appealed to Australians. It has been shown on the experimental farms that the generally accepted period of twelve years which must elapse before the tree comes to full bearing may be substantially shortened by suitable irrigation and tilling, and a return may then be looked for after four years.

In India the wild olive grows along the sides of the Afghan hills, and the European variety is now being introduced. Experimental work has been successful as far as it has gone, but it must be some years before Indian olive oil can come on to the market.

In South Africa the experimental stage has been passed and the olive is satisfactorily established in the Paarl district of the Cape and in parts of the Transvaal, and already small quantities of oil have been produced.

The wild olive grows abundantly in Cyprus, where the Government is encouraging the natives to adopt better methods of cultivation of the tree and of preparing the oil. At present the home requirements are barely met, but in the

* *Journ. Bd. Agric.*, 1915, **22**, 874.

opinion of W. Bevan (Director of Agriculture) it appears likely that a profitable export trade may in time be built up.*

The cultivation of the trees requires considerable attention, particularly with regard to weeding and prevention of disease and insect pests. Where the olive trees are grown for oil production the fruits are best picked just prior to maturity.

A good deal of olive oil is still produced in small local "oileries," and the fruit is crushed between a heavy revolving grindstone and a horizontal table, or an even simpler apparatus of the same form as a cider press is used, but the chief defect of these local presses is that they are not powerful enough to express the maximum quantity of oil. Modern machinery is installed in many factories and all grades of oil produced, the finest being obtained from the first light pressing. The kernels (which also contain oil) are not usually removed from the fruits.

Edible oils are not usually refined beyond settling and clarification by filtering. Lower grades are used for lubrication, burning, and for soap-making, and for oiling wool during spinning. After these oils have been pressed out, further treatment of the residual mass by boiling up or by allowing the mass to ferment in pits (when the oil gradually rises to the surface), or by solvent extraction, results in the production of various low-grade oils of high acidity, dark colour, and unpleasant odour.

The last small proportion of oil is usually obtained from the cake by extraction with volatile solvents. The residual cake is used for manure, as it keeps badly and is, therefore, not suited for cattle feeding.

EXPORTS OF OLIVE OIL (TONS).

	1909-1913.		1921.	1923.
	Maximum.	*Minimum.*		
France	7,421	4,961	4,857	16,011
Greece	20,776	2,748	11,163	—
Italy	40,999	23,635	13,798	—
Spain	60,723	26,106	47,291	—
Turkey	14,073	6,866	141	—
Algeria	9,280	1,546	1,839	—
Tunis	12,906	2,136	23,048	—

It may be noted that cultivation of the olive has decreased in Italy, France, and Greece, but during the period 1915-19 Spain almost doubled exports of oil, 110,498 tons being the export figure for 1919. Cultivation has increased of late years in Tunis, but the export figures for that country show great fluctuations.

Imports are distributed over a great many countries, and the largest importers are France, Italy, U.S.A., and Argentine.

It is noteworthy that imports of olive oil to Italy have assumed such large dimensions, and that exports have diminished. The imports for 1922, however, are only 4,161 tons.

* *Bull. Imp. Inst.*, 1919, 17, 508.

ANNUAL IMPORTS OF OLIVE OIL (TONS).

	1909–1913.		1921.	1922.
	Maximum.	*Minimum.*		
France	22,977	11,687	21,762	36,058
Great Britain and Ireland	16,713	8,984	2,342	4,984
Italy	5,761	894	11,249	—
Rumania	4,391	1,451	—	—
Russia	5,336	4,182	—	—
U.S.A.	19,485	13,733	24,374	27,315* / 11,947†
Argentine	26,909	17,029	14,079‡	—
Chile	3,983	2,823	1,759	—
Uruguay	2,453	1,446	2,445	—
Egypt	3,017	1,754	1,413	—

SESAME SEED.

Sesame seed is the product of an annual herbaceous plant, *Sesamum indicum* Linn. (Natural Order Pedaliaceæ), cultivated in many varieties throughout the warmer countries of the world and forming a most important source of edible oil in the countries where it is grown and also in Europe. The seed is known by various names—*e.g.*, "sim-sim," "teel" or "til," "ginjelly," and "benni" seed—and is used as an article of food (chiefly in sweetmeats) in Egypt and the East.

The chief producing countries are India and China, and as sesame is largely grown as a mixed crop in the former, and no statistics are available for the latter, it is impossible to arrive at any accurate estimate of the world's area devoted to this crop. The annual yield of sesame seed in India is estimated at between 400,000 and 500,000 tons, and in 1915-16 the area was 5,565,000 acres and the yield 551,000 tons.

An indication of the great importance of this oilseed is evident from a consideration of the exports of seed, especially when regard is given to the fact that enormous quantities of seed are consumed locally, though any attempt to gain an idea of the average yearly exports is almost hopeless owing to wide fluctuations from year to year.

The table on p. 67 shows the maximum and minimum exports, 1909-20, together with those for 1921 from the principal countries of origin.

Since 1895 the area of cultivation in India has extended greatly, the average yearly acreage for the period 1910-11 to 1914-15 being 5,177,000 acres, while some 4,466,000 acres were under this crop in 1921-22. It is quite obvious that the production of sesame seed has fluctuated widely in the past years, but speaking broadly China furnishes some two-thirds of the export supply, the remainder being derived from India and various African countries, most of the latter being British Possessions.

* Edible. † Crude, etc. ‡ 1920.

ANNUAL EXPORTS OF SESAME SEED (TONS).

Country.	1909–1920. Maximum.	Minimum.	1921.	1922.
Europe:				
Turkey	18,111	11,049*	—	—
Asia:				
China	168,891	13,280	88,093	—
Netherlands East India, Java, Madura	1,823	265	1,048	—
India	184,691	3,991	10,812	31,098
Indo-China	1,620	1	—	—
Nepal (since 1919) ..	1,015	225	225	—
Straits Settlements ..	1,162	300	354	—
Africa:				
Sudan	8,656	3,108	Not given	—
Nigeria	2,853	42	1,196	—†
Sierra Leone	130	—‡	38	—†
French Guinea	875	320	469	—
Kenya	5,631	1,345	Not available	—
Mozambique (up to 1913)	983	236	—	—
Uganda	2,150	47	1,003	—
Zanzibar, including ex-ports	1,021	5	808	—

British Empire's Requirements.

In considering the Empire's requirements of sesame seed it is a curious fact that sesame seed has never been utilized as a source of oil to any considerable extent in Great Britain; in 1917, 19,748 tons were imported into Great Britain, but 14,133 tons were re-exported; this figure has never been approached either before or since, while in 1921 and 1922 respectively only 2,994 tons and 74 tons were imported. Before the War only insignificant amounts were imported, chiefly for use in compound feeding cakes and not for oil manufacture.

Requirements of other countries in the British Empire are mostly met by home production, though India, Ceylon, Straits Settlements, and Egypt import small amounts of seed.

The lack of interest on the part of oilseed crushers in Great Britain is extremely hard to understand, as the seed offers no difficulties in working and furnishes a high yield of oil of excellent quality, together with a feeding cake of value for cattle feeding§ which is largely used on the Continent. One can only surmise that this fact is to some extent due to prejudice on the part of British oil crushers, as large quantities of seed are used on the Continent, chiefly in Germany, Spain, and France. In this connection one must take into consideration the fact that the demand for sesame oil on the Continent is partly due to the compulsory addition of the oil to margarine and other edible oil

* 1909–10 figures only available.
† Total export from British West Africa in 1922, 1433 tons (see Part II.).
‡ — does not mean no export, but no figures available.
§ *Bull. Impl. Inst.*, 1911, **9**, 272.

products (see p. 69), in order to facilitate the differentiation of butter substitutes from butter by simple tests.

The following figures will serve to show the esteem in which the oilseed is held on the Continent:

SESAME IMPORTS (TONS).*

	1909–1914.		1921.	1922.
	Maximum.	*Minimum.*		
Austria	42,126	16,917	—	—
Belgium	37,641	12,912	—	—
Denmark	6,020	—	3,292	—
France	97,893	19,301	7,130	11,292
Germany	114,205	76,709	34,601	15,677
Great Britain and Ireland ..	—	—	2,994	—
Netherlands	—	—	3,638	4,436
Spain	69,729	57,023	45,416	—
Japan	6,638	4,935	17,978	—

In France the sesame seed imports are dealt with almost entirely by the Marseilles oil mills, generally by the same mills as work ground-nut oil, and a portion of the Marseilles supply is "Levant" seed, derived from countries around the Mediterranean Sea.

The interest of various Continental countries (such as Germany) in this seed is obviously sustained, as large quantities are again being utilized at the present time by countries which were unable to obtain supplies during the War.

The possibilities of expansion of this crop within the British Empire are very great; there is already an excellent demand for the seed on the Continent, and it is impossible to conceive that oil manufacturers in Great Britain will continue for long to neglect the possibilities of sesame seed.

The cultivation of sesame seed should be capable of expansion in India, where it is already grown on an enormous scale, and the wide range of varieties of sesame capable of growth on varying soils and within fairly wide differences of climatic conditions should render its possibilities throughout the Empire worth very careful consideration. Attention to the value of sesame seed and its products was drawn as long ago as 1911 in a short but comprehensive article in the *Bulletin of the Imperial Institute*.† It was there pointed out that this seed was the most important oil seed of the Anglo-Egyptian Sudan, from which in 1909 over 6,000 tons of seed were imported, and in 1919, 12,225 tons, and where the opening up by railway of the Blue Nile should increase the output, and attention was also drawn to the fact that this crop is one of rapid growth which might easily be grown as a catch crop.

Within the last few years there is evidence of some development in most of the African Colonies (see British West Africa, East Africa, Egypt, and Sudan in Part II.), and even if no demand can be created for the seed in Great Britain it would be saleable readily on the Continent.

* Not including countries which have imported generally less than 6,000 tons

† 1911, 9, 259.

At Marseilles the sesame seed is bought on a grading system which takes into account size and colour of seed; thus, for example, " white " seed must not contain over 25 per cent. of dark seed (and allowances are claimed for over 15 per cent. of dark seed). Mixed dark and white (bigarré) seed must contain 25 per cent. or more of white seed. Sesame seed was quoted at £20 to £22 per ton (net cash in bags) on the Liverpool market during February, 1924, but the quantities of seed imported and used in the United Kingdom are relatively small (see Part II., United Kingdom statistics). The prices in England for sesame seed shipped to the Continent from Liverpool were as follows: Bombay seed, January to February, £27; Chinese seed, January to February, £26 5s. per ton in February, 1924.

Sesame Oil.

Although considerable amounts of this oil are produced and consumed—largely as food—locally in India and in other parts of the Empire where the seed is grown, there is no large export or import trade in the oil in any case, the largest annual export from India only amounting to 959 tons between 1909 and 1920.

It seems certain that if oil of good quality were exported from any of the countries of the Empire where the seed is grown it would meet with a ready sale, as the oil is largely used for edible purposes.* There is—as for the seed—but little demand for the oil in Great Britain, and imports of sesame oil to the United Kingdom have never been considerable; thus, imports in 1921 only amounted to 19 tons, valued at £1,006, and to 35 tons, valued at £2,178, in 1922. It should be possible to create a demand for the oil in the United Kingdom if regular supplies of oil of good quality can be guaranteed, as the value of this oil is certainly recognized at any rate by some British oil manufacturers and refiners.

Sesame Cake.

The cake produced in the manufacture of the oil is, when made from sound seed, a nutritious and valuable food for cattle and other stock, largely used on the Continent and also in India and other countries where the seed is worked for oil (the cake is sometimes even used as human food in times of scarcity in some countries).

Sesame cake does not appear among the imports to the United Kingdom in the official trade returns.

GROUND NUTS.

The ground nut, *Arachis hypogæa* (Natural Order Leguminoseæ), is very widely distributed in practically all tropical and subtropical countries, and is known under a variety of names, such as pea nut, monkey nut, goober pea, and

* Several Continental Governments have enacted that all butter substitutes shall contain sesame oil (which exhibits a very characteristic and simple chemical colour test) in order to prevent fraudulent sale as butter.

earth nut. The plant is an herbaceous annual, which possesses the characteristic of ripening its fruit in the ground—hence the names of earth nut and ground nut; this peculiarity of growth renders it necessary to have a fine surface tilth on the soil so that the delicate flower stalk may easily penetrate the soil, and renders the crop unsuitable for cultivation on heavy soils. In common with other members of the Leguminoseæ the plant has the property of enriching the soil in nitrogen, and this is an important fact from the cultivators' point of view.

The chief producing countries are India, West Africa, China, the United States, and the Dutch East Indies; the following table shows recent estimates of annual production:*

ANNUAL PRODUCTION OF GROUND NUTS.

India	1,100,000 tons.
United States	350,000 ,,
French West Africa	400,000 ,,
Dutch East Indies	200,000 ,,

An indication of the importance of China is given by the export figures (92,753 tons in 1921); no figures for actual production are available.

The world markets for ground nuts are chiefly supplied from India and British and French West Africa, both decorticated or undecorticated nuts being exported; owing to the cost of freightage, a large proportion of the nuts is decorticated, especially in the case of Indian exports. Decorticated nuts are, however, liable to undergo deterioration in transit, and in many cases large quantities arrive in such poor condition that the oil can only be used for soap manufacture and the cakes for manure. This may be partly due to the fact that, in order to facilitate removal of the shells, the nuts are often damped, and the subsequent drying of the kernels not carried far enough, so that the kernels heat during shipment and storage.

The importance of obtaining the best conditions for storage and shipping of the decorticated ground nuts, so that the oil may be good enough for refining for edible purposes, is obvious when it is remembered that 1 ton of ground nuts in shell represents only about 0·7 ton of kernel, the remaining 0·3 ton consisting of dirt and shell. Further, the kernels are but loosely enclosed in the shells, and the saving in cargo space on decorticating has been estimated at as much as 56 per cent.†

The largest importer of ground nuts has always been, and still is, France. In the years previous to the War France absorbed annually some 68 per cent. of the world's exports. For many years ground nuts were included under "unspecified oleaginous products" in the trade returns for Great Britain and Ireland, but the closing of the German market during the War diverted supplies to this country, and in 1917 ground nuts first appear as a separate heading in the trade returns.

During the War considerable amounts of ground nuts were imported, and

* *Oleaginous Products and Vegetable Oils, International Institute of Agriculture,* Rome.
† *Bull. Impl. Inst.,* 1917, **5**, 78.

it is to be hoped that they will remain an article of great commercial importance in the future, although imports will probably diminish to a certain extent owing to the gradual resumption of the pre-war demand by such countries as France, Italy, Holland, and Germany, and their consequent absorption of increasing quantities of ground nuts. At the same time the available supplies of ground nuts are on the increase, and it is to be hoped that Great Britain will endeavour to obtain a large share in the production of ground-nut oil and cake for home use as well as for export.

IMPORTS OF GROUND NUTS (TONS).

	1909–1913.		1921.	1922.
	Maximum.	*Minimum.*		
Belgium*	35,280	12,042	—	—
Denmark	3,608	1,169	4,642	—
France	485,670	373,355	382,423	66,886† 88,914‡
Germany	96,536	49,121	90,271	69,292
Great Britain and Ireland§ ..	—	—	95,403	65,756
Italy	40,230	24,382	68,964	—
Netherlands	66,363	51,355	28,785	13,840
Russia	3,303	946	—	—
U.S.A.	13,684	1,479	17,929	1,595

It may be noted that Japan is now becoming a large importer of ground nuts, the import figure for 1921 being 14,972 tons.

Although the great bulk of the exports come to Europe, the U.S.A. have, since the War, been increasing their imports, though it is possible that the planting of former cotton areas with ground nuts may in the future affect the import position.

EXPORTS OF GROUND NUTS (TONS).

	1909–1913.		1921.	1922.
	Maximum.	*Minimum.*		
China‖	67,916	55,464	92,753	—
Dutch East India	21,836¶	19,822¶	12,020	—
French Settlements in India ..	105,544	67,786	19,777	—
India	255,066	119,604	171,230	235,891
Straits Settlements	6,384	3,979	1,669	—
British West Africa:				
Gambia	67,404	47,931	59,175	86,868**
Nigeria	19,288	995	50,979	
French West Africa, chiefly Senegal††	238,255	168,422	261,748	—
Kenya	7,010	1,222	—	—
Tanganyika	—	—	—	12,518‡‡

* Since 1913 imports included under "unspecified oleaginous products."
† In shell. ‡ Decorticated. § Included in "other unspecified nuts" prior to 1917.
‖ Of late years the exports include an increasing quantity of decorticated nuts, 68,374 tons in 1921.
¶ 1912 and 1913 figures only available. ** Total for British West Africa.
†† Since 1917 an increasing proportion of nuts exported are decorticated. ‡‡ 1922.

Ground-Nut Oil.

Before the War most of the ground nuts coming to Europe were crushed in France, the remainder going almost entirely to Belgium, the Netherlands, and Germany. The effect of the War on the large producing countries has been to encourage local treatment, for the difficulties of transport have been such that large proportions of the main crops have had to stay in the countries of origin. At the beginning of the War considerable difficulty was found in disposing of the crops of several of our colonies, but it now appears that this difficulty has been to the advantage of the countries concerned, notably in the case of Burma. Ground-nut cultivation has only come into prominence there within the past twenty years. There is a large local consumption of oil, and in 1911-12 more than 2 million gallons were imported, whereas in 1917 this figure was reduced to about 700,000 gallons; the oil-crushing industry is being developed in Burma by European firms on sound lines, and the industry appears to be in a strong position. The production of ground-nut oil in India must be very considerable, but the oil is evidently consumed locally, as exports of oil have not exceeded 1,600 tons since 1912-13, and only amounted to 240 tons in 1922.

The keeping qualities of this oil are very good, and in this respect ground-nut oil ranks amongst the best of all liquid vegetable oils, which is of obvious importance in view of the fact that shipments of oil are likely to increase. Ground-nut oil of fine quality is chiefly used in the manufacture of margarine and other edible fats, while considerable quantities of the oil are hardened; the lower grades of oil, such as are obtained from decorticated kernels of poor quality, are used —especially in France—for soap manufacture.

Before the War the only countries exporting large quantities of ground-nut oil were France, China, Holland, and Germany. The two former still retain the premier position, but figures from several other countries are beginning to assume significant proportions.

EXPORTS OF GROUND-NUT OIL (TONS).

	1909–1913.		1921.	1922.
	Maximum.	*Minimum.*		
United Kingdom	—	—	2,335	1,354
Belgium	1,309	615	2,022	—
France	25,926	18,476	40,181	—
Netherlands	9,929	5,731	8,087	7,541
U.S.A.	—	—	763	447
China	18,101	14,675	27,489	—
Dutch East Indies	39	1	1,097	—
India	1,190	—	—	240

Ground-Nut Cake.

Ground-nut cake is one of the most valuable for cattle-feeding purposes on account of the high content of protein, and it is also a good manure. It is becoming increasingly popular as a feeding cake in the United Kingdom, and

its value better known as time goes on. The producing countries are now realizing the value of keeping the cake and meal for their own consumption, and it would seem likely that local treatment of the seeds will increase.

The exports of ground-nut cake from India are large; in 1912-13 about 62,000 tons were exported, and in 1922 about 80,000 tons. The demand in the United Kingdom for the cake is considerable (see Part II.), and a large proportion of the imports is derived from India; in 1922, 47,654 tons were from India out of a total import of 59,519 tons.

Castor Seed.

The castor plant (*Ricinus communis*) grows wild in practically all tropical and many subtropical countries, and belongs to the Natural Order Euphorbiaceæ, to which various other plants of economic importance, such as the Para rubber tree (*Hevea brasiliensis*) and the tung oil tree (*Aleurites* species), also belong. In tropical countries the castor plant is of the dimensions of a small tree; in the subtropics it is a shrub of about 8 to 12 feet; and in countries where frosts occur it is a herbaceous perennial. The main value of the crop is the oilseed, but in India the leaves are used as fodder for cattle and as food for the Eri silkworm.

A very large number of varieties of castor seed are under cultivation, but on the whole the seeds fall into the two main categories of large and small, the former giving a more prolific yield of seeds, and the latter a finer oil. Commercial supplies of seed are chiefly derived from India, and are composed of small seed, which possesses one great advantage—viz., that of occupying small cargo space; while small seeds are also rather less liable to damage in removal of husks or during shipment.

The castor plant has a well-developed root system, and therefore deep ploughing of the soil is necessary; it rapidly exhausts the soil, and therefore the residual cake, obtained after expressing the oil, together with the empty capsules, leaves, and stems, are advantageously returned to the soil as manure. The seed consists of about 20 per cent. husks, 80 per cent. kernels, and contain about 50 per cent. of oil; they also contain a poisonous substance, ricin, and in addition a fat-splitting enzyme or lipase, which has been employed for the saponification of oils for production of fatty acids and glycerol.

In India the castor plant is not often grown as a pure crop, but generally as a border to cotton or sugar fields, or mixed with potatoes, cereal, and leguminous crops; grown in this way exhaustion of the soil is not so rapid. Castor is a troublesome crop to harvest, as it is necessary to gather the capsules in which the seeds are enclosed before they ripen. In most varieties the ripening of the seed extends over a considerable period of time. After drying the capsules usually open and scatter the seeds, or the outer husks are removed by a roller or by threshing.

Although the great bulk of castor seed in the world's markets is produced by India, Brazilian seed—which first assumed noteworthy proportions during the War—is now of some importance. The United States grow the plant, but in insufficient quantity to supply their own demand. It is also cultivated in Man-

churia, Java, and Indo-China, but it is not possible to form any conclusions as to the areas under castor.

The War created an increased demand for castor oil, and this is reflected in the many attempts in British Possessions to extend cultivation; for example, serious attempts have been made to establish the industry in Cyprus.

EXPORTS OF CASTOR SEED (TONS).

	1909-1913. Maximum.	1909-1913. Minimum.	1921.	1922.
Brazil	4,153	31	14,167	—
India	130,720	90,487	29,621	85,000
Java and Madura	1,771*	1,461*	2,368	—
Africa (total)	—	—	332	—

IMPORTS OF CASTOR SEED (TONS).

	1909-1913. Maximum.	1909-1913. Minimum.	1921.	1922.
Belgium	18,476	11,273	†	—
Germany‡	—	—	—	—
Great Britain and Ireland	64,957	54,772	13,033	18,438 §
Italy	12,923	10,889	2,285	—
U.S.A.	21,809	8,624	15,021	—
Japan	—	—	3,252	—

A study of the countries to which the Indian exports go reveals, however, that, in addition to those mentioned in the above tables, very considerable quantities of seed are taken by France, Italy, Germany, and Spain. The great increase in Indian exports in 1921 and 1922, compared to 1920 (in which they were about half those of the subsequent year), was chiefly due to the enormously increased demand from America, which in 1921-22 took nearly half the entire Indian exports.

Castor Oil.

It will be noticed that the Indian export trade in castor seeds suffered considerably during the War, although at the same time there is an increase in the exports of oil, showing, in common with so many other Indian oil seeds at that time, that expression was encouraged in order to conserve freightage. The great demand that arose for the oil during the War for lubricating aeroplane engines has, in the natural course of things, declined, but there is little doubt that the oil will always have considerable demand as a lubricating oil. It is a very valuable lubricant owing to its exceptionally high viscosity, and probably much of the oil that comes into or is manufactured in this country is used for this purpose. It is also somewhat extensively used in the manufacture of "Turkey red oil" (*i.e.*, sulphonated oil for use in the dyeing industry). Comparatively small quantities are used medicinally, for which purpose only the best

* Figures only available for 1912-13.
† Included in other unspecified oleaginous products.
‡ Figures include soya, shea, mowra, and are therefore omitted.
§ Valued at £305,437.

cold-pressed oil is employed, as under these conditions of manufacture the poisonous ricin does not pass into the oil.

If any surplus of oil should be available it would be useful to the soap manufacturer. The oil cannot be used for edible purposes, notwithstanding the fact that the physiological properties are almost entirely destroyed by modern deodorizing processes.

It is used by the natives for many purposes: for lubrication, dressing leather, and to some extent for lighting, although in this direction it has been largely replaced by kerosene.

EXPORTS OF CASTOR OIL (TONS).

	1909–1913.		1921.	1922.
	Maximum.	*Minimum.*		
Belgium ..	5,567	3,862	1,218	—
France ..	3,483	2,878	2,085	2,104
Great Britain and Ireland ..	10,849	40*	3,919	4,195
Italy ..	643	226	360	—
Brazil ..	—		607	—
India† ..	6,075	4,049	780	—
Indo-China ..	647	24	677	—

It is interesting to note that, excepting Germany, the bulk of the imports of oil are to British Possessions, and are largely obtained from Great Britain and India. The Indian export figures for oil, however, show a drop for 1921, and are, in fact, the lowest recorded figures for a long period.

IMPORTS OF CASTOR OIL (TONS).

	1909–1913.		1921.	1922.
	Maximum.	*Minimum.*		
Austria ..	2,995	2,419		—
France ..	788	216	438	530
Germany..	9,376	6,718	3,722	3,508
Great Britain and Ireland ..	1,868	1,345	510	2,515
Italy‡ ..	23	11	482	—
Canada ..	2,042	374	446	—
Japan ..	727	275	294	—
Africa ..	790	1,154	508	—
Australia ..	2,453	1,269	—	—
New Zealand ..	789	541	150	—

Castor Cake.

The cake is very rich in nitrogen, and on this account is, in India, one of the most valued cakes for manure; it is largely used for potato and sugar crops, and its value is also recognized by the tea planters. Considerable quantities are

* Re-exports. † 9,664 tons in 1918.
‡ 1918, 2,190 tons; 1919, 2,880 tons; 1920, 984 tons.

exported to Ceylon, and the market gardeners of France use thousands of tons annually. It cannot be used for cattle-feeding on account of the presence of the poisonous ricin, and although satisfactory experiments have been carried out recently with a view to destroying the activity of the ricin by heating to a high temperature,* it will probably be difficult to induce users of feeding cakes to set aside their long-standing prejudice against castor cake.

FATS

COCONUTS AND COPRA.

The coconut is without doubt the most important oil-bearing tree of warm climates, and its distribution is exceedingly wide. It is the source of various products of great importance to the natives of the countries where it grows, and also to the world in general.

The coconut palm, *Cocos nucifera*, belongs to the tribe Cocoineæ, of the Natural Order Palmeæ, and this tribe includes many of the other oil-yielding palms, such as the West African and cohune palms.

There are many varieties of coconut palm in cultivation showing differences in habit of growth, yield, and size of fruit, but the tree is essentially a tropical one, and though it may grow in districts up to the twenty-fifth degree of latitude N. or S., the nuts hardly ever ripen at these extremes. The very wide distribution of this palm is no doubt partly due to the fact that it is grown abundantly on the shores close to the sea, and the nuts can be transported by ocean currents without suffering damage.

The tree attains a height of something between 50 and 100 feet at maturity, and very frequently assumes an angle of 45 degrees with the ground, and this fact becomes of importance in considering the space to allocate to new trees on plantations.

The leaves form a tuft at the apex of the trunk, and are about 15 to 20 feet long. The flowers grow from a branched spadix enclosed when young in a tough sheath, and the fruits, which take about a year to reach maturity, are usually three-sided, and more or less ovoid in shape.

The chief products derived from the coconut palm are: (1) Coconuts; (2) copra (the dried meat of the coconut); (3) coconut oil; (4) coir fibre.

The importance of products (1), (2), and (3) to the fat industries of the world can hardly be over-estimated. Coconut oil has for long been the mainstay of the margarine manufacturer, and is used for the preparation of all types of edible fats. The fact that supplies can be accurately estimated and come regularly into the country, since harvesting occurs all the year round, is of great importance. Weather conditions affect this crop much less than, for example, linseed or cotton, and, in consequence, prices of copra generally do not fluctuate to any great extent.

Practically every part of the tree finds a use among the natives. For example,

* *Journ. Bd. Agric.*, 1918, **24**, 1444.

the leaves are used for roof coverings, mats, etc., the leaf stalks for fences, and handles for tools, and the fibrous sheaths of the leaves for material for mats. The unripe nuts contain a refreshing drink, and the ripe nuts yield coconut-milk. The husks give fibre which finds various uses in brushes, mats, etc. The intoxicating drink known as "tuba" in the Philippines and "toddy" in the East is produced by "tapping" the flower spathe before it opens, and on allowing the liquid obtained to ferment the spirit "arak" is produced from the toddy by distillation. If the juice is evaporated before it ferments, palm sugar or "jaggery" is obtained.

The coconut palm grows best near the sea-shore, where there is plenty of light and breeze, and where the temperature has a mean average of about 80° F. It requires a considerable amount of moisture, in no case less than 40 inches, and if the rainfall is as low as this a rich moisture-retaining soil is necessary; 60 to 80 inches is more advantageous. The coconut palm flourishes on the alluvial flats along the sea-coast and the mouths of rivers, and a deep, fertile, sandy loam is probably the best soil of all, but much may be done in poorer soil by suitable draining and manuring. It appears to appreciate a calcareous soil, and humus or decayed organic matter is essential.

It has frequently been stated that the coconut requires a soil containing salt, such as is found along the coast, and it certainly flourishes on almost pure sea sand impregnated with salt. The fact that many plantations have succeeded in inland situations shows that the coconut will flourish without salt, though salt certainly appears to be beneficial, as is indicated by the results of manurial experiments carried out recently at Porto Rico.* In these experiments the plot to which salt was applied yielded forty-five nuts per tree, while the check plot averaged eleven nuts per tree. The results were so promising that further experiments on older trees are being made, and planters have been recommended to try the application of 3 to 4 pounds of salt to the roots of each tree.

An annual yield of from 5,000 to 6,000 nuts per acre is common from trees in full bearing, but if this yield is to be maintained manuring is absolutely necessary, and is practised in the plantations. A very extensive literature has grown up in connection with the cultivation of the coconut palm, and the agricultural authorities of most of the countries concerned have experimental stations, and issue directions and advice to the planters concerned. A great deal of attention has also been given to the various pests attacking the tree.

The tree takes from seven to ten years to reach the fruiting stage, and then continues bearing for some eighty years, a good crop for each tree being from fifty to seventy nuts per year. Since the flower spathes are produced in succession during the year, it follows that the nuts are in various stages of ripeness at any given time, so that care is necessary in harvesting to ensure that only the ripe ones are gathered. As a rule natives climb the trees and throw down the ripe nuts, from which the outer fibrous husk is then removed (hulling) either by striking each individual nut on a spike of iron or hard wood, and subsequently pulling off the fibrous coat, or by means of a decorticating machine which can deal with 500 to 1,000 nuts per hour.

* *Journ. Jamaica Agric. Soc.*, 1923, **27**, 673.

Coir Fibre is obtained from the husk by first retting and then either beating by hand or passing through a crushing machine. After drying and willowing the fibre is sorted into grades, the finer or " mat " fibre for spinning and for mats or ropes, the stiff " bristle " for brushes and brooms, and the short " curled " fibre or tow for use in upholstery.

Desiccated Coconut.—This product is largely employed in confectionery, particularly in the United Kingdom, the United States, and the Continent of Europe, and is prepared from fresh coconuts by shredding and drying the " meat." Ceylon is the largest manufacturer of this product, but it is also manufactured in various countries which import the fresh whole nuts. The outer brown skin of the kernel is taken off by a shaving and rasping process, and the kernel cut in two and drained, after which the material is passed through a shredding machine, and then dried. Oil is recovered from the material obtained on removing the skin, but this oil has rather different properties from ordinary coconut oil made from the whole " meat," and cannot be sold as such.* The exports of desiccated coconut from Ceylon are as follows:

	1909–1913. (*Tons*).	1921. (*Tons*).	1922. (*Tons*).
Maximum	15,190	43,526	—
Minimum	11,540		

Coconuts.—A large trade is carried on in the nuts themselves (freed from the outer husk), and compared with other oilseeds it is somewhat remarkable that coconut exports and imports seem to have been only slightly affected during the war period.

EXPORTS OF COCONUTS (TONS).

	1909–1913. *Maximum.*	1909–1913. *Minimum.*	1921.
Cuba	10,907	4,479	2,677
British Honduras	6,554	4,871	7,259
Honduras Republic	—	—	12,648
Panama Republic	6,206	3,149	6,822
Jamaica	23,770	13,401	24,224
British Guiana	1,043	712	2,761
Trinidad and Tobago	20,603	16,305	21,551
Ceylon,	18,405	15,723	23,739
Africa (total)	614	422	610
French Oceania	1,983	871	1,179
Portuguese India	36,180	2,909	—

IMPORTS OF COCONUTS (TONS).

	1909–1913. *Maximum.*	1909–1913. *Minimum.*	1921.
Italy	89	21	10,700
Canada	4,473	3,297	5,[illegible]63
U.S.A.	—	—	79,991
Barbados	450	321	1,306
India	11,924	8,429	5,963
Egypt	—	—	3,248

* Bolton and Revis, *Fatty Foods*, p. 151.

The general tendency appears to be for the larger producing countries to export fewer coconuts and increasing quantities of copra and oil, while what may be termed "Oceania," comprising the Pacific Island groups, deals almost entirely in copra, and Central and Southern America and the West Indian Islands almost entirely in coconuts.

In dealing with trade in coconuts the various returns have been made comparable, to some degree at least, by converting returns based on numbers of nuts into long tons by assuming 1,000 nuts to the ton.

Copra.—Copra, or dried coconut meat, is an exceedingly important article of commerce. It is produced by first breaking the husked nuts in halves, draining off the "coconut milk," and exposing the two halves of the nut to the sun. After a few hours' drying the meat shrinks far enough to allow of its removal from the shells, and the "meat" is then subjected, with frequent turning, to a further period of drying. Sun-drying may be complete in four to five days, but in some climates takes considerably longer. It is often necessary to provide shelter against rain, and drying trays with wheels running on rails are often used, so that the trays can readily be run under cover to avoid exposure.

COPRA IMPORTS (TONS).

	1909–1913.			
	Maximum.	*Minimum.*	1921.	1922.
Austria	47,451	33,074	14,323	—
Belgium	41,668	19,243	10,438	—
Czecho-Slovakia	—	—	14,021	—
Denmark	30,652	—	66,139	—
France	175,848	110,860	69,437	113,294
Germany	193,492	110,387	200,936*	282,676
Great Britain and Ireland ..	30,868†	—	54,865	86,084‡
Netherlands	100,615	60,963	114,838	168,446
Russia	59,874	72,007	—	—
Canada	468	108	1,320	—
U.S.A.§	30,450	11,037	99,813	112,812
India	437	40	4,920	—
Japan	2,862	1,545	7,959	—
Straits Settlements‖	91,983	73,086	126,169	
Union of South Africa	—	—	1,335	—
Australia	12,131	5,861	38,896¶	—

Sun-drying, especially if combined with a preliminary treatment with sulphur fumes to destroy fungoid growths, yields good results, but climatic conditions do not always render it practicable. It is often necessary to resort to artificial drying, and natives often still use the primitive method of smoke-drying, in

* Twelve months ending April 30, 1922.
† Included in "other unspecified nuts" prior to 1913.
‡ 30,428 from Straits Settlements, including 14,324 from Ceylon.
§ Including coconut meal and desiccated coconut.
‖ Largely from Malay States and mostly re-exported.
¶ Year ending June 30, 1920.

which the copra is dried on lattice trays over a slow fire, but the resulting copra is liable to be partially charred and darkened by smoke, and yields an inferior oil. Drying of copra is also often done in sheds or kilns heated by means of a long furnace flue running under the floor—this may be constructed simply by digging a trench, which is covered with sheet iron and then with a layer of sand. Drying in a kiln of this type generally takes about 36 hours, but naturally depends on various factors such as the turning of the copra. Probably the most economical method is that of drying in sheds heated by steam pipes, but in the case of the smaller plantations the initial outlay is often too great. A large number of drying machines of various types are on the market, but native methods are still those mainly in use.

In every case it is necessary to dry down to a maximum moisture content of 5 to 6 per cent., otherwise the copra will be attacked by various micro-organisms which cause loss of oil, and heating of the copra on storage or shipment, and a bad coloured oil.

An accurate estimate of the total of the world's exports of copra is almost impossible, owing to the many sources of supply and the inclusion in statistics of important shipping centres—such as the Straits Settlements—of material produced in other countries.

The following statistics for exports from the chief countries of shipment serve to indicate the relative importance of the chief sources, and the rapid growth of the copra industry since the commencement of the present century.

	1900 (*Tons*).	1913 (*Tons*).	*Maximum during* 1900–13 (*Tons*).	1921 (*Tons*).	1922 (*Tons*).
Philippine Islands	57,361	75,000	138,300	138,231	170,588
Dutch East Indies:					
Java	35,257	78,800	107,709	89,138	49,690
Macassar	13,982	30,711	38,821	65,863	67,628
Other Dutch East Indies	15,783	44,297	49,012	57,268	66,104
Straits Settlements	28,214	90,765	102,946	132,705	169,800
Ceylon	18,059	51,962	51,962	68,785	84,339
Malabar	21,000	37,201	37,202	2,360	18,870
Total	189,656	408,736	—	554,350	627,019

The total exports of copra from the South Pacific Islands is estimated by competent authorities at 100,000 tons a year, though any detailed analysis of the supplies from these sources is impossible owing to the lack of statistics in many cases. Supplies are also exported from various African Colonies—particularly Zanzibar—from Indo-China, Borneo, the West Indies, and other tropical countries. The table on p. 81 includes the available statistics of exports in 1921-22 from the more important of the sources referred to above and not included in the previous table of exports.

In 1922 the imports of copra to the chief buyers, the United Kingdom, France, the United States of America, Germany, and Holland, amounted to over 763,000 tons; making only a moderate addition for imports to other countries,

it can be assumed with confidence that the total imports exceeded 800,000 tons in 1922.

	1921 (*Tons*).	1922 (*Tons*).
South Sea Islands:		
Fiji	14,531	21,987
French Settlements	6,846	—
New Hebrides	5,268	—
Solomon Islands	12,109	—
New Guinea	23,735	—
Western Samoa	7,428	—
Australia (re-export)	30,686	—
Africa:		
Zanzibar	12,982	12,673
Tanganyika	3,492	—
Kenya and Uganda	467	1,660
Mauritius	193	597
Asia:		
Indo-China	9,352	—
West Indies	2,000	—
Seychelles	2,579	—
British Borneo	2,787	—

Figures for 1923 are not yet available, but the prospects of increased exports from various sources were expected to result in a total in the neighbourhood of 900,000 tons.

It is very interesting to note the changes that the War occasioned in the exports and imports of copra. Before the War the British Empire had an exportable surplus of about 30 per cent. of the world exports, made up as follows, showing 1921 figures for comparison:

	1913 (*Tons*).	1921 (*Tons*).
Ceylon	55,865	68,372
India	38,192	3,099
Federated Malay States	9,269	36,209
Unfederated Malay States	19,208	—
Seychelles	2,938	2,579
Tonga Islands Protectorate	3,426	—
Fiji	7,929	14,531
Papua	845	—
Solomon Islands	4,196	12,109
Gilbert and Ellice Islands	3,500	5,000 (1919)
East Africa Protectorate	1,564	1,111 (Kenya and Uganda)
Zanzibar	9,451	12,982
Gold Coast	629	443
Trinidad	515	1,873
Total	157,527	—

A very large proportion of this trade was with Germany. For example, three-quarters of the Ceylon exports in 1913 went to Germany and four-fifths of those of India. The produce of the Malay States was mostly sent to the

Straits Settlements, whence it was re-exported, and two-thirds of the Seychelles copra went to France, while Australia took a fair proportion of the Tonga and Fiji Islands exports. France and Germany were the largest European importers, with the Netherlands and Russia next. During the War the volume of trade shrank, but not in every direction equally. The producing countries were variously affected. The total exports from Asia declined almost to one-half, while from Oceania they increased continuously throughout the War, and doubled by 1918. Imports to Europe diminished largely owing to Russia and Central Europe ceasing to import, but imports to Denmark, France, and Holland also showed a decline. On the other hand, imports to the United Kingdom were maintained until 1918, when there was a sudden drop; the latest import figures to Great Britain, however, show a big increase. At the same time the U.S.A. very materially increased their imports from 17,544 tons in 1913 to over 200,000 tons in 1918, and Japanese imports also increased.

The years succeeding the War witnessed a recovery of the European imports. Germany is again importing large quantities and has even exceeded her pre-war imports, and in 1922 had again become the biggest copra-crushing country in the world. Australia is very greatly increasing her imports, most of which are from the Pacific Islands, and are re-exported to European and other countries. As would be expected, the export figures for most countries for 1919 are exceptionally large owing to shipment of accumulated stocks.

The price of Singapore f.m.s. copra, c.i.f. London in 1922, ranged between £24 19s. and £25 6s. 6d. This is less than half the maximum price of 1920—viz., £69 10s., and considerably less than in 1921, when the price dropped from £37 10s. in January to £27 in December.

The following are prices of some of the different grades of copra in London on February 15, 1924, spot prices in bags 10s. per ton less in bulk:

	Per Ton. £	s.
Malabar (f.m.g.w.s.)	33	0
Ceylon (f.m.s.)	32	10
Seychelles (f.m.s.)	31	5
Java (f.m.s.)	30	10
Straits (f.m.s.)	30	5
South Sea (f.m.s.)	29	15
South Sea (kiln-dried)	29	0

Prices in Liverpool and Antwerp are the same as in London; in Holland the better grades are 10s. or £1 a ton more; the lower grades about the same as in London.

Coconut Oil.

Coconut oil is produced in the tropics partly by native methods and partly in mills equipped with modern machinery. Native methods are sometimes very crude and may consist simply in exposing small pieces of copra to the heat of the sun and collecting the oil as it runs off. A better way consists in crushing the copra and pressing it in wooden presses, or the pounded copra is thrown into boiling water and the oil skimmed off the surface. Great care is often

exercised by the natives in preparing the oil, and oil of excellent quality is prepared in some cases—*e.g.*, Cochin oil.

The oil first came into use in Europe for soap manufacture in the middle of last century, and it was not until much later that its value for use as an edible oil in such products as margarine was appreciated.

Various grades are on the market which vary according to the method of preparation; thus the highest grade oils are known as Cochin oils, the next grade is Ceylon oil, and the rest copra oil. Originally Cochin oil was prepared on the Malabar coast, and its superiority over Ceylon oil is probably partly owing to the longer seasons of dry weather and partly to the greater care taken in cultivation and preparation. Copra oil, as its name implies, is obtained from copra. Modern methods for producing it are in use in Europe, U.S.A., and also Australia. These usually consist of an expression process resulting in the production of oil and coconut cake, though it is sometimes the custom to submit the residue from the first pressing to extraction by solvents. The extraction process is not usually applied to the raw copra, as the copra is so rich in oil, and the bulk of the oil is obtained so readily.

Coconut oil after refining is very largely used in the manufacture of all types of vegetable butters, either as the whole oil or, if a firmer fat is required, as the pressed stearine; the softer oleine may either be refined for edible purposes or used for soap.

As in the case of copra exports and imports the War has had a marked influence on the production and trade in coconut oil. Up to 1914 most of the oil was manufactured in Europe, France and Germany taking the first places, but gradually the copra-producing countries began to come to the front, notably in the case of the Philippine Islands and India, and since the War the exports of oil from these two sources have been largely maintained. The U.S.A. and Japan came to the front during the War both as regards copra imports and later coconut oil exports, but their oil-export trade has since diminished; other producing countries have also diminished their exports of oil, but in the case of the Philippine Islands ever-increasing areas are under coconut cultivation, and expansion is still likely to occur in their exports. Nearly all the Manila coconut oil exported in 1922 went to the U.S.A. protected by a 20 cents per gallon import duty, and this duty appears to have had a very good effect on the crushing industry. The Ceylon trade is very large and has remained on the whole at a very constant level. A coconut oil industry sprang up in Dutch East Indies during the War, and exports of oil in 1921 reached the neighbourhood of 30,000 tons, and were even greater in 1919, reaching the huge figure of 68,000 tons. However, the industry has not survived the changed trade conditions, and in 1922 export dropped to 10 tons.

The prices of coconut oil vary with the origin of the oil: during 1922 East Indian Ceylon oil varied between 37s. and 41s. 6d. per hundredweight, while East Indian Cochin oil fetched from 41s. to 47s. 6d c.i.f. London. The higher of these prices obtained in January, and the December price for the Cochin oil was 44s. 9d. In February, 1924, crude oil was 47s. per hundredweight in Liverpool in casks (all other prices net, naked).

Coconut-Oil Imports (Tons).

	1909–1913. Maximum.	1909–1913. Minimum.	1921.	1922.
Belgium	5,590	3,219	14,816	—
Germany	7,125	328	29,883	—
Great Britain and Ireland	61,659	33,975	53,224	38,390
Netherlands	31,063	12,185	31,337	1,215
France	3,795	1,282	5,290	—
Norway	3,579	1,110	4,367	—
Denmark	6,539	2,305	2,599	—
U.S.A.	32,228	19,505	84,690	81,198
Dutch East Indies*	5,353	3,880	3,783	—
Federated Malay States	1,495	1,099	1,294	—
Egypt	1,375	999	2,263	—

Coconut-Oil Exports (Tons).

	1909–1913. Maximum.	1909–1913. Minimum.	1921.	1922.
Belgium	9,913	1,077	4,697	—
Denmark	6,287	1,214	4,565	—
France†	44,242	10,520	6,204	—
Great Britain and Ireland:				
Exports	15,064	5,073	2,025	—
Re-exports	5,603	3,625	2,697	—
Netherlands	5,291	3,047	63,413	—
Ceylon	30,984	20,089	24,236	27,722
Dutch East Indies*	1,533	1,597	38,051	10
India	10,799	4,603	6,526	4,959
Philippines‡	4,931	—	88,865	102,860
Straits Settlements	9,722	6,528	9,792	—

Coconut Cake.

Coconut cake, which usually contains about 7 per cent. of oil, has come into wide use for purposes of cattle feeding, both in the United Kingdom and abroad. It is highly nutritious, and can be used for practically all livestock. Experiments on its value for dairy cows show that it is a very satisfactory food for the milk producer, and it compares very favourably with linseed cake. It is not too concentrated to feed alone, and its value is becoming well recognized. Considerable exports of cake take place from the large coconut-producing countries (*e.g.*, see details under India and Ceylon).

The Oil-Palm Industry, Palm Oil, and Palm Kernels.

As both palm oil and palm kernels are derived from the same tree, the West African oil palm, *Elæis guineensis* Jacq. (Natural Order Palmæ), and as the production of palm kernels depends to a very large extent on that of palm oil, it is logical, and at the same time convenient, to deal with both products together.

The oil palm is a handsome tree bearing large bunches, termed "heads" or "cones," of fruit which are commonly of bright orange colour, and occurs

* No figures available prior to 1912. † Including mowra and palm-kernel oils.
‡ No figures available prior to 1913.

in Africa between the latitudes of 16 degrees N. and 12 degrees S. The oil palm flourishes from Gambia to Angola, chiefly along the coast belt, but is also widely distributed on the continent of Africa even as far south as the Zambesi River, and occurs in East Africa in Uganda, Tanganyika, and also on the island of Zanzibar.

The commercial exploitation of the oil palm of Africa is practically confined to West Africa, Nigeria being the most important producer of palm oil and palm kernels.

It is hardly necessary to mention that the introduction of a tree of such great commercial importance has long since been attempted experimentally in many tropical countries, but it is a curious fact that until a comparatively recent date nothing approaching commercial success had been attained, and the enormous amounts of palm oil and kernels used in the world's markets have been produced in West Africa from wild or almost uncultivated palms. Moreover, the palm oil was produced entirely by native labour using wasteful though ingenious methods, whilst the kernels were obtained by the laborious process of cracking the nuts by hand.

At the present time the oil palm is being exploited commercially on an increasing scale, and with evident success in the Dutch East Indies*—chiefly in Sumatra—and both in Sumatra and Malaya the oil palm has proved very precocious, yielding larger quantities of fruit, and also commencing to bear fruit at a much earlier age than in West Africa. The planting of the oil palm in Sumatra was commenced in 1911 at various places in the east of the island. Early in 1917 only 6,500 acres had been planted, but by January, 1922, the area had been increased to over 28,000 acres, and manufacture of palm oil was being carried on. The extension of cultivation in the East in the near future seems certain; in fact, in Malaya "several large areas have been taken up for the purpose of growing the palm on a commercial scale. The Governments of the four States (Perak, Selangor, Negri Sembilan, and Pahang) are reserving large areas of land exclusively for this crop, and land will be given out on specially favourable terms" (*Rep. Dept. Agric. Fed. Malay States*, 1919).

Experiments have also been made in other British Possessions—*e.g.*, Ceylon, where the locality of plantation does not appear to have been very favourable, as the rainfall was insufficient, and where irrigation appears to have been necessary.

The oil palm appears to grow well in the moist regions of Brazil, and the Amazon region may in the future become an important source of supply.

It is not proposed to discuss here in any detail the nature of the oil palm, its distribution and exploitation, but in view of its great importance to West Africa, and the likelihood, one may say certainty, of its increasing importance in other parts of the Empire, it seems advisable to give a brief description of the climatic and soil requirements of the oil palm together with a few brief notes on the methods of exploitation.†

* *Investigations on Oil Palms made at the General Experiment Station, A.V.R.O.S.*, Medan., 1922.

† The literature referring to the oil palm and its products is already voluminous. For full details respecting the African oil-palm industry the reader may be referred to a series of articles in the *Bulletin of the Imperial Institute*, which summarizes in a convenient form all the most important data (see Bibliography).

For luxuriant and highly productive growth the oil palm requires a moist, equable climate such as occurs in the equatorial zone of West Africa, and although it grows in tropical regions with marked wet and dry seasons, these conditions do not favour quick growth or productivity.

The mean annual temperature should be between 71° and 86° F., the average optimum being about that suitable for cacao—viz., 77° F., with a rainfall of between 70 to 100 inches a year distributed in numerous small falls alternating with sunny weather.

The oil palm appears to do well on many kinds of soil, but, generally speaking, rich but not heavy alluvial soils are best; ample moisture is essential, and land liable to flooding is often suitable provided that the trees are not exposed to stagnant water for long.

The areas of oil palms in West Africa from which supplies of fruit are obtained often receive little or no attention, though such simple measures as thinning out of trees and removal of undergrowth and superfluous leaves are practised in a good many districts, and are known to be most beneficial.

The extraordinary yields of fruit obtained from cultivated trees in East Sumatra show emphatically that the oil palm readily responds to care, and that such care is amply repaid. As might be expected with a tree of such wide distribution, the oil palm exists in many different varieties; these have been more or less exhaustively examined by numerous botanists, and are now classifiable into a few fairly definite types. There is no need to describe these here in detail; it will suffice to say that the most common and widely distributed type bears fruit with a comparatively thin pericarp or outer pulp (the source of palm oil) and thick-shelled nuts, but that there is another type (widely distributed, but nowhere abundant) bearing fruits with a thick pulp with thin-shelled nuts.

It is evident that the latter type of fruit, which gives a high yield of palm oil, and contains nuts and kernels the shells of which are easily cracked, is preferable to the first-mentioned type.

It is, however, not possible at present to say whether cultivation of the thin-shelled type would be more profitable than the ordinary type, as it is not yet definitely settled how the two types compare, when grown on a large scale, in productivity of fruit, nor is it decided that the thin-shelled type can be grown true to seed, or that it will not gradually revert to the thick-shelled type. There is, however, evidence to show that the oil palm varies in productivity, and it is therefore likely that the selection of seed for planting from productive strains will eventually result in improvement of yield, as has been the case with other plants (*e.g.*, rubber) of economic importance.

In West Africa the production of palm oil and kernels is carried out on primitive lines. The fruit is gathered from wild or semi-cultivated trees, near the villages, and the oil prepared in small quantities at a time, and generally sold to local traders, who collect the produce and forward it to the coast for shipment. The collection of fruit from full-grown trees entails the climbing of the tree; this is a task of some difficulty, and in some districts it is not easy to find sufficient natives capable of carrying out this operation.

The native methods of preparing palm oil vary in different districts, and are probably dependent to some extent on local conditions (such as water and fuel supply), and also on local custom or prejudice. The different methods result in the production of palm oil varying in quality from the high-grade "soft" Lagos oil, containing but little free fatty acid, to the lowest grade "hard" oils, such as Salt-pond, where a large proportion of the oil has become converted to free fatty acid.

Broadly, it may be said that the soft oils are produced from freshly gathered fruit by cooking the fruit with water, removing the softened pulp, and squeezing out the oil from the pulp; the oil is then heated until it separates from the water, and is skimmed off and strained.

The hard and semi-hard oils are generally produced by processes which depend on allowing the fruit to heat or ferment in heaps for varying lengths of time; in this way the pulp is readily softened, but the acidity of the oil is enormously increased, and its quality and value lowered.

The rise in acidity of the oil is caused by the decomposition of the oil into free fatty acids and glycerol; this decomposition is caused largely, if not entirely, by a fat-splitting enzyme (or lipase) present in the fruit pulp, which enzyme is set free from the cells of the fruit pulp when the fruit is bruised, and which acts rapidly when the fruit pulp is warm and moist, under conditions such as occur in a heap of fruit. Bacterial and fungoid action are possibly also active factors of decomposition of oil.

Numerous attempts have been made to devise improved simple methods or to induce natives to adopt the best of the known methods, and although oil of good quantity can be, and is, made by native methods, all the methods are wasteful and result in the loss of a great deal of the available oil. One of the chief causes of this appears to be the lack of efficient means of pressing the oil out of the fibrous pulpy matter.

Simple hand-operated machines have been devised for making palm oil,* the principle of working generally being one of subjecting the fruits to the action of rotating beaters in a vessel filled with hot water, but it does not appear that such machines have been adopted to any considerable extent, although several trials were made with one of the machines in the Gold Coast Colony.

Palm Oil.

The different grades of palm oil appearing in commerce vary considerably in appearance and quality; the high-grade oils are a brilliant orange colour, only contain small percentages of free fatty acids, are easily refined and decolorized, and have a characteristic, not unpleasant odour; the low-grade oils contain large percentages of free fatty acids, vary in colour from yellow to greyish white or dirty brown, are generally difficult to decolorize, and possess a most unpleasant odour.

The nearly neutral oils are of soft pasty consistence at temperatures normal

* *Bull. Impl. Inst.*, 1917, **15**, 64; 1913, **11**, 210.

in Great Britain, and are classed as "soft"; the low-grade oils are much harder owing to the high percentage of free fatty acids, and are classed as "hard."

The grading of palm oils on the English market is based on allowances for dirt and/or moisture, and on the free fatty acids (see p. 39).

Palm oil is chiefly used in civilized countries in soap and candle manufacture; when freshly prepared by the best native methods it is largely used by natives in West Africa as food, and the possibility of employing the oil in the manufacture of margarine and edible compounds has attracted much attention for several years past. It is of interest to note that palm oil has been used successfully in recent years as a fuel in internal-combustion engines (see Bibliography).

Palm oil possesses some very desirable qualities from the point of view of margarine and edible fat manufacture, perhaps the chief being that of possessing a suitable consistence. It possesses, however, certain distinctly undesirable characteristics, among which may be mentioned the fact that, although palm oil, or at any rate the better grades, may be treated so as to render it colourless, odourless, and tasteless, both colour, odour, and taste are liable to revert to some extent on keeping. Palm oil has been, and still is being, used in increasing quantities in the United Kingdom and possibly on the Continent in the manufacture of margarine and other edible compounds; and its use in this way is certain to increase in importance; but, so far as the authors are aware, edible palm oil can only be produced from the higher grades of crude palm oil (supplies of which are limited at present), and even these offer considerable difficulties in refining, deodorizing, and decolorizing. With regard to decolorizing, it is quite obvious that complete decolorization of palm oil is not essential, particularly if the amount of palm oil to be used in a "compound"—*e.g.*, margarine—is small; unfortunately the colouring matter of palm oil possesses peculiar characters which render certain processes of refining (generally employed for edible oils) impossible without previous decolorization. Progress in the refining of palm oil for edible use is certainly being made, and the fact that the colour, like that of many other oils, is removed by hydrogenation has opened an interesting field of possibility and research.

The above remarks may be considered somewhat lengthy and even outside the scope of the present book, but so much has been said in the past at various times about palm oil as an edible oil *without due appreciation* of the inherent technical difficulties of refining the oil for edible purposes, that a word of warning may not be out of place.

The very stringent requirements as to taste, odour, colour, keeping quality, and behaviour when used in cooking, etc., to which edible oils must now conform are only known to and grasped by those who have had long and painful experience of the production and use of such materials, and the fact that an oil is largely used for human consumption in its country of origin does not of necessity afford proof of its suitability for the manufacture of margarine or edible "compounds" by other nations.

Prices of palm oil in Liverpool in February, 1924, were approximately as follows:

Grade.	Net £ per Ton, Ex-Quay Packages included.
	£ s. £ s.
Lagos	40 5 to 40 10
Fine Red Sherbro	41 0 „ 41 5
Bonny/Old Calabar Benin/Pt. Harcourt	38 15 „ 39 0
Half Jack, Grand Bassam, etc.	38 0 „ 38 5

The oils are sold subject to the terms of contract No. 21, Liverpool United General Produce Association (see p. 39).

Palm Kernels.

The production of palm kernels is a matter of extreme simplicity: the nuts obtained after the removal of pulp from fruit used in making palm oil or gathered from the ground under the trees are *dried* and cracked—generally by women—by placing the nut on one stone and striking it with another; drying of nuts is necessary to cause the kernel to separate from the shell. Obviously this is a laborious and slow operation, and several small portable machines for cracking palm nuts have been devised, one of which, at any rate—a British made machine—has proved deservedly popular, and is used to a fairly considerable extent. After shelling by machine, separation of broken shell from kernels is necessary; this may be effected by hand-picking, or by placing in a solution of brine in which kernels float and shells sink, while several machines have also been devised for the purpose. The use of nut-shelling machines has, in some localities of West Africa, resulted in a large increase in the production of kernels. The following figures indicate the great importance of palm kernels in British West African trade:

Exports of Palm Kernels from West Africa.

	1909–1913.		1921.	1922.
	Maximum.	*Minimum.*		
British West Africa:*				
Gold Coast	14,628	9,744	1,651	Not available
Nigeria	184,625	158,849	153,354	178,723
Sierra Leone	50,751	42,892	40,409	49,029
Cameroons	19,251	13,015	18,794	Not available
French West Africa ..	50,488	35,496	42,278	yet

Palm kernels are generally shipped in bags or baskets, though consignments in bulk were made for a time during the War, and are sold on a basis of 49 per cent. of oil with allowance for variation in oil content (see p. 39).

Reference to the increased importance of palm kernels in the United Kingdom since the War will be found in Part II.

The price of palm kernels in Liverpool on February 18, 1924, was £20 12s. 6d. to £20 15s. on 49 per cent. of oil basis.

* Gambia omitted (450 tons in 1922).

Development of the Oil-Palm Industry.

For a good many years past attention has been given to such questions as the care of the oil palm, its cultivation in plantations, the possibility of utilizing machinery for the production of oil and kernels. Considerable progress has already been made and knowledge gained of scientific methods of cultivation and exploitation, though much work yet remains to be done.

The possibility of utilizing machinery for the production of palm oil and kernels is one which has given rise to the exercise of much ingenuity, and has resulted in the production, by both British and foreign firms, of machinery which has been used in factories which have been worked for some years past in various parts of West Africa and in Sumatra, though the quantities of palm oil and kernels produced in such factories up to the present only amount to a small fraction of the total.

It is not possible to enter here into details of methods of cultivation of the oil palm, or of the machinery for the manufacture of oil,* but in view of the importance of the oil-palm industry it is of interest to consider very briefly the principles of mechanical manufacture of the oil and in what direction development of the oil-palm industry is likely to take place.

The mechanical treatment† of palm fruit for production of oil and kernels involves broadly:

(*a*) Removal of the fruits from the heads or bunches. This may be effected by hand by beating, while machines have also been devised for the process.

(*b*) Expression of palm oil from the fruit pulp, either by pressing the whole fruit or the pulp alone after removal from the fruit.

(*c*) Drying and shelling the nuts and separating kernels from shells.

The most important factor in the preparation of palm oil by any method is the observance of such precautions as will prevent the formation of large amounts of free fatty acids due to decomposition of glycerides by the active fat-splitting enzyme. It is therefore necessary to work up the fruits as rapidly as possible, to avoid the use of over-ripe and bruised fruits, and to heat the fruits as soon as possible to such a temperature as will "kill" the enzyme. This is effected by boiling or, more effectively, by steaming the fruits, and some authorities recommend steaming the whole bunches, as this renders easy the removal of fruits from the bunch.

The whole fruits are then pressed in cage presses at low pressure, after which the remaining pulp is removed from the nuts by a depulper and pressed again at high pressure, or the fruit is first depulped and the pulp treated separately. Various types of depulpers have been designed; these generally employ mechanical beaters and brushes which remove the pulp, and grids which separate the pulp from the nuts.

Although anything in the nature of a prophetic forecast is certainly dangerous, there can be little doubt that the present methods of production of oil and kernels on a small scale by native methods will be replaced gradually by large

* Information on machinery for treatment of palm fruit will be found in *Bull. Impl. Inst.*, 1909, 357; 1913, **11**, 206; 1917, **15**, 57.

† For full details of machinery see references given in Bibliography.

factories employing efficient labour-saving machinery and capable of producing oil of better and more uniform quality, though how long this change may take, and how far it will be complete, it is, of course, impossible to say.

The establishment of a factory for the production of palm oil and kernels in some district in West Africa may sound at first sight a simple problem, involving merely the erection and running of an efficient plant in an area where palms are plentiful and the population sufficient to supply labour for collection of fruit and in the factory. In point of fact it is far from simple. Even assuming that suitable machinery has been selected, the whole success of the venture must depend on an *ample and regular supply of fruit* being obtainable. Unfortunately, reliable data as to the average annual yields of fruit obtainable from a definite area of wild oil palms are practically non-existent (or, if existent, are not available), so that no really safe estimate of the area required to supply the factory can be made.

Assuming further that a suitable area is located, it remains to come to some arrangement whereby the supply of fruit can be assured, and this at once brings up the questions of "concessions," of native labour, and of possible interference with native rights and customs, difficulties which have so far prevented exploitation of the oil palm in British West Africa Colonies.

We have reason to believe that some of the factories established (outside British West Africa) encountered great difficulties in ensuring such regular and ample supplies as to enable the factories to be operated profitably, and it seems almost certain that rational development of the industry can, in many cases at least, only take place on plantation lines even where—as in West Africa—large areas of wild palms already exist. The chief reason for this being that a much larger area of wild or semi-cultivated oil palms must be worked and that the costs of collection and transport of fruit would probably be as great as, or even greater than, the cost of intensive cultivation on plantation lines of a smaller area producing a high yield of fruit. Further, fruit produced from a comparatively small plantation area would reach the factory in fresh condition, which is a most important factor in relation to the quality of oil produced.

The cultivation of the oil palm in plantations, and the manufacture of oil on a commercial scale by the Dutch in Sumatra,* has given excellent results, and there seems little doubt that the high yearly yields of fruit obtained there, some of which are far higher than are common in West Africa, are chiefly due to the effects of cultivation, and that similar high yields would be obtained from oil palms grown in West Africa under plantation conditions.

Briefly, one may expect to see within the next few years a considerable development in planting the oil palm in various tropical parts of the British Empire, such as Malaya, British Guiana, the Seychelles, and possibly also in the West African Colonies, where the palm is indigenous (though large scale exploitation here is chiefly dependent on questions of policy),† and central factory production of oil and palm kernels will follow as a natural sequence.

* A. A. Rutgers, *Mededeelingen Algemeene Vereeniging van Rubberplanters ter Oostkust van Sumatra. Algemeene Serie*, No. 6, 1919; No. 8, 1920; abstract *Bull. Impl. Inst.*, 1920, **18**, 209.

† See Part III

Shea Nuts.

These nuts are obtained from the shea-nut tree, *Butyrospermum Parkii*, of the Natural Order Sapotaceæ, and are often given the name " karité " nuts, but as Lagos shea nuts exported into French colonies are known to be re-exported under the name karité nuts, the two names appear to be quite interchangeable. The shea-nut tree is confined to Africa, roughly to a belt north of the Equator, extending from French Guinea on the West to the White Nile on the East, and as far south as Togoland and Uganda. Wherever the tree occurs it is used by the natives, and the nuts have been exported during recent years from West Africa, chiefly from Nigeria.

The shea-nut tree grows to a height of 45 to 60 feet and bears fruit from May to September, but the fruits mostly ripen in July. The tree does not grow near the coast, but prefers a deep soil rich in humus, such as is often found round the clearings of villages. It is found in the forest and bush, but does not attain its maximum growth in such situations and is often damaged by bush fires. Laws are in force in many districts, such as the Upper Senegal and Nigeria, to prevent the cutting down of the tree when land is being cleared. Since the tree does not bear fruit until it is twelve to fifteen years old, and reaches maturity at thirty, it is not likely that plantations will be made, but the proper clearing of overcrowded trees is to be strongly advocated and possibilities for the extension of the shea-nut industry are receiving considerable attention. A survey has recently been made in the Gold Coast, where the Conservator of Forests has recorded the opinion that the trees in the Northern Territories are capable of producing 260,000 tons of shea butter per annum, and the Agricultural Department is actively collecting data with regard to yields of nuts produced on certain 10-acre plots, the annual girth measure of trees, etc., and also working on problems connected with the elimination of unsaponifiable matter from the fat.

The fruits, about 1½ to 2 inches long, consist of an outer yellowish or blackish green pulp, which is eaten by the natives and also by animals such as sheep and swine, enclosing usually one nut. The nuts are about 1 to 1½ inches long, and have a light brown, thin, woody shell (which is easily removed on drying), and a soft yellowish kernel. The kernels turn to a dark chocolate colour and become firm and hard when dried, in which state they are exported. Approximately 5¼ tons of fruit are required for the production of 1 ton of dried kernels. The fruits drop when ripe, and the outer pulp is either removed by washing or left to rot away, after which the nuts are dried and the shells taken off by crushing in a mortar. Drying of the kernels is either carried on in the sun or by means of a rough kiln, but the latter method often causes damage to the kernels and affects the quality of oil produced. Depulping and nut-cracking machines and more modern methods of drying are now being introduced in some districts. The dried kernels as shipped contain about 50 per cent. of fat.

Shea Butter.

The native method of preparation of shea butter usually consists of roasting the kernels (which makes them easier to work and is said to coagulate the latex and thus to prevent much of it being subsequently extracted with the fat), crushing in a mortar or between flat stones, and boiling up the mass with water, skimming off the fat, and purifying it by treatment with water and straining. By this means only about half the fat is extracted, and this is often dark-coloured and has an unpleasant burnt smell. When carefully prepared the fat is white, of a firm consistency and a not unpleasant odour, and valuable for edible purposes. It should be noted, however, that this fat contains a fairly high proportion of unsaponifiable matter (5 to 7 or 8 per cent. is usual), which is not removed by the ordinary refining methods, and detracts somewhat from its value. It is, however, gradually becoming better known in many countries, and is being used in Europe for the preparation of various cooking and "compound" fats.

In spite of the possible disadvantages of containing a high percentage of unsaponifiable matter—a disadvantage the importance of which has, in the authors' opinion, been somewhat over-estimated—the fat is otherwise of excellent character; it possesses a desirable degree of consistence, and when treated by modern methods of refining, deodorization, and decoloration produces an edible fat of good quality. The introduction of modern oil mill machinery to West Africa for the treatment of shea nuts and other oilseeds has long been talked of, and it is noteworthy that, while exports of shea nuts have somewhat diminished, those of the butter have increased.

The exports of shea nuts from West Africa are almost entirely from British West Africa. The maximum export from British West Africa is that of 1915—viz., 10,084 tons; in 1922, 6,717 tons were exported.

French West African exports are small from 1918 to 1922; the largest export was that of 1922—viz., 109 tons of nuts—while 295 tons of shea butter were also exported.

Small quantities of butter are also exported from the Sudan (*e.g.*, 409 tons in 1920) and the Ivory Coast (110 tons in 1919).

There is little doubt that great development of the West African shea-nut industry is possible, the chief problem being the improvement of means of transport to enable the large undeveloped areas to be economically worked. Although shea nuts are exported to Europe, and have been for some years past, it may be contended that the value of shea butter and the methods of refining it are not very widely known at present, so that large consignments of the kernels may, at first, not meet with a very ready sale or reach very high prices. There is, however, no doubt that the kernels will eventually meet with a ready demand at prices bearing a fair relation to those paid for well-known oilseeds such as palm kernels and ground nuts, and shea-nut kernels may be expected in the future to play an increasingly important rôle in British West African trade.

BORNEO TALLOW.

True Borneo tallow is derived from various members of the family Dipterocarpeæ, which grow in Borneo, Sumatra, and Java. The most important source of the fat is *Shorea stenoptera*, and it is also obtained from *Shorea Ghysbertiana*, *Shorea aptera*, *Shorea robusta*, and from *Isoptera borneensis*.

A great deal of confusion exists as to the trade and botanical names of this and other somewhat similar fats which are indiscriminately referred to under the indefinite name of "illipé."

The seeds to which the name illipé is given fall into three main classes:

1. The *Bassia* seeds of India (Natural Order Sapotaceæ), including *Bassia latifolia*, which yields "mowra" fat, *B. longifolia*, and *B. butyracea*, yielding "phulwa" butter.

2. The "siak" seeds, species of *Palaquium*, small nuts also belonging to the Sapotaceæ, sometimes called "small siak nuts."

3. The *Shorea seeds*. These are often known as "Large Pontianak," or "Sarawak" (towns in Borneo) "illipé nuts" to distinguish them from Class 2.

It is thus obvious that great confusion has resulted from so wide an application of the term illipé, and the indiscriminate use of the word is greatly to be deprecated.

The various *Shorea* nuts are marketed largely according to their colour. The black nuts are considered the best and contain nearly 70 per cent. of fat, while the brown ones as a rule have only 48 to 50 per cent. The trees bear fruit after about twelve years and the fruits are collected as they drop. No real cultivation of the trees can be said to take place and the fruiting depends largely on the season.

The winged calices are removed from the fruits and then the nuts are shelled. To effect this a very usual practice is to subject the nuts to prolonged soaking (thirty to forty days), which causes the shells to split and allows the kernels to be easily removed. Owing to the length of time required by the process the nuts are often placed in damp places and allowed to germinate, after which the shells are removed and the sprouts broken off. This however, has a bad effect on the contained fat. The method of preparation probably accounts for the colour of the product. A large part of the export trade in these kernels is through Singapore.

Borneo tallow is used by the natives as an edible fat and in Manila for the manufacture of candles; in Europe it is readily saleable for the manufacture of cacao butter substitutes for use in chocolate manufacture. In view of the fact that cacao butter is an extremely valuable fat, Borneo tallow of good quality sells at high prices, as also do genuine "Borneo illipé kernels" when *in good condition*. The kernels are, however, liable to damage during preparation and transit, and commercial consignments sometimes yield fat of high free fatty acid content; it is therefore desirable that contracts for illipé kernels should include a clause defining allowances in price according to free fatty acid content.

The meal, after removal of fat, is suitable for use as a cattle food, but is not so valuable in this respect as palm-kernel cake. It is, however, readily saleable.

Vegetable Tallow (Chinese).

Although vegetable tallow is not produced in any appreciable quantity within the Empire, it is of interest to mention briefly the source and methods of preparation, because fair quantities are exported from China to the United Kingdom, and also because the vegetable tallow tree has been introduced to Northern India, where it grows well, and might with advantage be grown elsewhere in other parts of the Empire. The tree also grows in Indo-China, and has been introduced into South Carolina. Vegetable tallow is derived from the fruits of the Chinese tallow tree, *Stillingia sinensis* (Natural Order Euphorbiaceæ). This tree commences to bear fruit at an age of four or five years, and when fully grown will produce 55 to 65 pounds of fruit a year. In China the leaves are used in dyeing silk.

The fruit is a schizocarp splitting into three cocci enclosed in an outer brown husk; this husk splits off, leaving the cocci exposed. The latter consist of an outer white tallowy layer (mesocarp)—the source of *vegetable tallow* and a inner nut composed of a hard brown shell enclosing a soft kernel containing a liquid oil with marked drying properties.

The fruits yield three distinct products according to the method of working employed.

1. *Vegetable tallow* (" pi-yu "), derived from the outer mesocarp alone, obtained by steaming the whole unbroken seed in perforated vessels, or by removing the outer layer (by passing the fruits through fluted rollers which scrape off the outer layer), and pressing this separately.

2. *Stillingia oil* (" ting-yu "), obtained by crushing and pressing the seed alone after removal of the tallow. This oil is reputed to be poisonous.

3. *Mixed tallow and oil* (" mou-ieou "), obtained by crushing and pressing the whole seed without removal of the outer tallow layer. This material is naturally much softer than the pure tallow from the outer layer alone.

The seeds yield about 20 per cent. of tallow and 19 per cent. of liquid oil. The pure tallow—" prima " vegetable tallow—is very hard and brittle, and has a characteristic tallow-like taste and smell, the " secunda " vegetable tallow contains more or less of the liquid oil from the kernel. In Europe vegetable tallow is chiefly used in soap and candle manufacture, but is also employed for stiffening softer edible fats.

The production in China is very large; considerable quantities are used locally for edible purposes and for candles, while fairly large quantities are also exported, chiefly from Hankow. The following table shows the shipments from China, together with the chief importers in 1912-13 and in 1921.

	1912–13 (*Tons*).	1921 (*Tons*).
Total shipments to:		
United Kingdom	3,565	1,713
The Continent	5,050	
New York	827	1,410

The average monthly prices of white China vegetable tallow in London varied in 1913 from 30s. to 35s. 9d. per hundredweight, and in 1922 from 39s. 3d. to 41s. per hundredweight. The present price is 44s. per hundredweight.

Cocoa Butter.

This is the name commonly given to the fat obtained from the cocoa bean, *Theobroma cacao*, and is not to be confused with coconut fat. The world's output of cocoa beans in 1920 was something like 379,700 tons, and in the production of cocoa a large proportion of the contained fat is pressed out. The whole cocoa bean contains 40 to 50 per cent. of fat, and the nib—*i.e.*, the bean after removal of the husk—from which cocoa and chocolate are made 45 to 55 per cent., while cocoa as sold usually contains 20 to 25 per cent. of fat.

It will be seen, therefore, that about two-thirds of the fat is pressed out, and when one considers the volume of the cocoa trade, it follows that the cocoa butter trade must also be very large.

This excess of cocoa butter is, however, to a great extent used up in the manufacture of chocolate, often in the same factory in which the cocoa butter has been expressed, for chocolate contains more fat relative to the cocoa matter than is naturally present in the nib used. The magnitude of the trade in cocoa butter is not, therefore, evident from figures of imports or exports which merely represent an adjustment between the manufactures of cocoa and chocolate.

Cocoa butter at the present time finds little use apart from chocolate manufacture. During the War, however, when there was a large increase in cocoa consumption, and a corresponding decrease in chocolate consumption, the excess of cocoa butter came on the market and was used as a cooking fat.

In normal times more fat is required for chocolate manufacture than is available as cocoa butter, and many cocoa-butter substitutes are on the market (for example, refined Borneo tallow, and coconut and palm-kernel stearines).

The following figures serve to show the extent of the import trade in cocoa butter into the United Kingdom:

1913	912 tons, chiefly from the Netherlands.
1920	909 ,, ,, ,,
1921	286 ,, ,, ,,
1922	1,216 ,, ,, ,,

Export figures from the United Kingdom of cocoa butter manufactured at home are only available from 1920, as previously they were not recorded separately.

1920	2,048 tons	(649 to Canada, 971 to foreign countries).
1921	1,271 ,,	(471 to Australia, 227 to Canada, 379 to foreign countries).
1922	955 ,,	(769 to Australia, 91 to Canada, and only 17 to foreign countries).

It will be noticed that in 1922 the bulk of the exports went to Australia, and that export to foreign countries other than British Possessions had practically ceased.

Mowra Seed.

Mowra seeds are produced in very large quantities in India, and are amongst those to which the term "illipé" is applied (see note on illipé under "Borneo Tallow, p. 94"). Botanically they belong to the *Bassias* (Natural Order Sapotaceæ). The name mowra was probably applied in the first instance only to the seeds of *Bassia latifolia*, which is practically confined to Central India. It now, however, includes the seeds of *Bassia longifolia*, a tree which grows further south. Consignments of mowra seeds from Southern India usually comprise an admixture of seeds of the two sorts of *Bassia*, but shipments from Central India are generally only those of *Bassia latifolia*.

Another member of the *Bassia* family is *Bassia butyracea*, which yields a finer and more valuable fat (known as "phulwa" butter) than the mowra seed.* The local demand for this fat is considerable, and the seed never appears to find its way to Europe in any quantity.

These three species of *Bassia* are practically confined to India. They are not cultivated in the ordinary acceptance of the term, and though the trees are widely distributed, in many cases they grow in little populated and inaccessible districts.

It may be mentioned that *Bassia* flowers are very widely used by the natives as food and as a source of spirituous liquor, and it has been computed that in the Hyderabad State alone there are sufficient *Bassia* trees for the production of 700,000 gallons of proof spirit per annum in addition to local requirements. As the corollas of the flowers only are usually used after they have fallen from the trees, production of the seed is not interfered with, except that dead leaves, grass, etc., under the trees are cleared away to facilitate the collection of the flowers, and natural regeneration is hindered.

The tree is well able to stand drought, and is suitable for planting on waste and dry land, but it takes some twenty years before seeds are produced in large quantities. The collection of the seed is a difficult problem owing to the somewhat inaccessible and sparsely populated districts where the trees chiefly grow, and probably large quantities of seed are lost. It is not likely that the fat exported, only sufficient being made for local consumption, but the export of seed is on a fairly large scale.

Exports of mowra seed are irregular, and the figures given differ very much according to the authorities consulted, probably owing to the great variations from year to year in the crop harvested, and the fact that the different compilations do not always refer to identical periods.

The following figures are from the *Review of Trade of India*:

Exports of Mowra Seed from India (in Tons).

Pre-war average	29,000
1919–20	2,000
1920–21	5,000
1921–22	1,000

* The composition of the fats of the three species of *Bassia* was investigated by one of the present authors (*Journ. Soc. Chem. Ind.*, 1912, 31, 98).

In both 1911 and 1913 about 28,000 tons went to Germany, but after that France took increasingly large quantities and the residue came chiefly to the United Kingdom.

Owing to difficulties of collection the seeds often arrive in this country in rather poor condition, and consequently the fat obtained from them is high in acidity, and the cost of refining is increased.

The fats of *Bassia latifolia* and *B. longifolia* are softer than Borneo tallow, and find extensive use in India as ghee substitutes (where religious tenets forbid the use of animal fat), for anointing the body, and for various other purposes. In Europe their chief use is for candle and soap manufacture.

The cake left after pressing is bitter, and though opinions differ as to its poisonous properties it certainly cannot be recommended for cattle feeding. This is a considerable drawback in considering the economic value of the seed, and the only use for the residual cake or meal would appear to be as a not particularly valuable manure. Some *Bassia* cake or meal finds a use in horticulture, where the poisonous saponin present in the cake renders it useful as a worm killer for use on lawns or golf greens.

Japan Tallow.

This material is, owing to its appearance, more commonly known as Japan wax; it is in reality a hard fat derived from the berries of various species of trees of the sumach tribe, such as *Rhus vernicifera* (the source of Japanese lacquer), which occurs in China, Indo-China, and Japan, while certain species—*e.g.*, *Rhus succedaneæ*—occur in Northern India. The berries yield 15 to 25 per cent. of greenish tallow-like fat, which is prepared in a similar manner to Chinese vegetable tallow (see p. 95), and is clarified and bleached before export.

The exports from Japan are fairly considerable. It is used as a wax for floors and in polishes.

Price of Japan tallow, February, 1924, £4 17s. 6d. per hundredweight.

TALLOW, LARD, AND ANIMAL FATS

Beef and mutton tallows are the fats derived from the various fatty tissues of cattle and sheep respectively. Lard is fat derived from pigs, while various other animal fats, such as neat's-foot oil (*i.e.*, oil from the feet of cattle) and bone fat, are also articles of commerce.

The "rendering" or boiling out of fats from animal tissues is essentially a simple process, formerly carried out in open fire-heated vessels; nowadays fat rendering is classed in most countries as an offensive trade, and, except on a small scale, or in uncivilized countries—is effected in steam-heated vessels with outlets connected to the chimney to avoid escape of offensive vapours, or in closed digesters or autoclaves. In the preparation of tallow for technical purposes the rough fat from the slaughter-house is placed in lead-lined tanks fitted with steam coils; hot water is then run on to the fat and the steam turned

on. When the heating has been continued for a sufficient length of time the clear melted fat is run off and, if necessary, subjected to further purification.

The animal tissue which remains, and still contains a good deal of fat, is again steamed after the addition of dilute sulphuric acid, which breaks up the cell membranes and also destroys emulsions. The second stage of the process yields tallow somewhat inferior in odour and colour to the first stage.

The rendering of animal fats is carried out on an enormous scale in the United States, the Argentine Republic, and elsewhere. Rendering is chiefly carried out in closed digesters or autoclaves; these consist of large boilers with false bottoms, on which the fat rests, and the rendering is carried out (often under steam pressure) by admitting live steam below the perforated false bottom of the digester.

It will be seen that the processes of rendering tallow, lard, etc., are comparatively simple operations. The quality and characters of the products depend, however, on a number of factors, such as the part of the animal used, the condition of the rough fat, the temperature employed, and the care with which the process is worked.

Ordinary tallow is the fat obtained by rendering various fatty tissues. For the manufacture of high-grade fat, such as is employed in margarine manufacture under the name of "premier jus," the kidney fat (suet) and bowel fat is worked up separately, and not mixed with the other parts of the animal. The fatty tissues are removed immediately after slaughtering, chilled immediately to remove animal heat, and rendered at a low temperature. Extreme care is taken in preparation, and the premier jus is generally clarified by treatment with fuller's earth and filtration.

Premier jus is also separated—by allowing it to partially crystallize or "grain," and then pressing in hydraulic presses—into "oleo" or "oleo-oil" of soft buttery consistency and hard "oleo-stearine," the consistence of either of which is adjusted according to requirements by varying the pressing.

Oleo-oil is almost entirely employed in margarine manufacture, while the stearine is occasionally used in margarine, but mostly in other edible fats such as compound lards and suet substitutes.

Generally speaking, mutton tallow is harder than beef tallow, is more liable to turn rancid, and has a rather stronger and more unpleasant flavour than beef tallow, and is consequently less suitable for manufacture of edible fats, but carefully rendered mutton tallow really shows little inferiority to beef tallow.

Various kinds of lard are recognized in commerce; originally the term was applied only to the fat derived from the "leaf" (the fat of the kidneys and bowels), of the pig, but its use has now been extended to fat from any part.

In the rules of the Chicago Board of Trade the following edible grades of lard—depending on the source and method of manufacture—are recognized:

1. Neutral lard No. 1.
2. Neutral lard No. 2 (imitation neutral lard).
3. Leaf lard.
4. Choice lard, choice kettle-rendered lard.
5. Prime steam lard.

The first of the above grades is lard obtained by rendering the leaf at a low temperature (40° to 50° C.); the second is rendered similarly from the black fat. Both these grades having been rendered at a low temperature, and not "cooked," do not keep well, and are therefore not used for domestic purposes, but for margarine and edible fats, which are consumed soon after manufacture.

The third grade—leaf lard—is obtained by rendering under pressure the residual tissues after removal of the first grade (1), as above. The fourth grade —choice lard—is obtained from the tissues left after the preparation of neutral lard No. 2 (or an admixture of these and tissues from No. 1) by steam rendering in open kettles or in digesters. The last grade of edible lard—prime steam lard —is rendered in digesters from any trimmings not used for previous grades, and from other parts of the animal except liver, lungs, intestines, and part of the heart.

Other non-edible grades, such as "yellow grease," "white grease," and "brown grease," are worked up from various parts of the animals, from refuse fat obtained in making edible grades, and from animals which have died.

The non-edible grades of tallow and animal fats are chiefly employed in the manufacture of soap, and for the production of fatty acids for candle manufacture (see p. 27). The value of such fats for soap and candle manufacture depends to a large extent on the consistency of the soap which they will yield, or on the melting-point of the fatty acids, and for commercial purposes such fats are usually sold on the "titre" test (see p. 32). Certain animal oils, such as neat's-foot oil and lard oil (the liquid portion of lard), are used for lubricating, thus neat's-foot oil is particularly valuable for delicate machinery, but is principally consumed in the leather industry as "fat liquoring" for manufacture of fine grades, such as glove leather. Lard oil is also still used as an illuminant.

The production of animal fats such as tallow and lard is carried on more or less all over the world, the chief sources of exports of tallow being Australia and New Zealand, North America (chiefly the United States), South America (the Argentine Republic and Uruguay), while the United States is the largest producer of lard. China also exports tallow in considerable quantities.

Figures for home production and consumption are in most cases not available. In the United Kingdom the consumption of animal fats is very large, as considerable quantities are imported in addition to home produced supplies. Figures for the home production of tallow, etc., in the United Kingdom are not available, but it has been estimated that about 100,000 tons of tallow were produced in 1900.*

SHIPMENTS OF TALLOW (TONS).†

	1913.	1922.
Australasia	73,300	62,700
Argentina	41,177	30,353
Monte Video	10,746	8,974‡
United States:		
Tallow	—	20,970
Oleo-oil	—	48,837
Oleo-stearine	—	10,138

* Lewkowitsch, ii. 757. † *Review Oil and Fats Market.* ‡ 1921.

The above statistics of shipments, etc., of tallow, lard, etc., from the chief exporting countries serve to indicate the magnitude of the export trade in these materials.

The extent of the South American meat industry can be judged from the number of animals slaughtered during the 1921-22 season: "Saladero" killings in the Plate, 1,152,800; "Frigorific" killings, 2,187,353.

UNITED STATES OF AMERICA. STATISTICS FOR LARD, ETC. (TONS).

	1913.	1922.
Hogs killed (number)	18,920,645	29,406,000
Production of lard (tons)	—	701,062
Exports ,, ,, ...	256,916	351,539
Consumption ,, ,, ...	—	349,523

The largest export of lard since 1892 is that of 1921—viz., 398,608 tons.

IMPORTS OF TALLOW AND OTHER ANIMAL FATS IN 1922 (TONS).

	United Kingdom.	*France.*	*Holland.*	*Germany.*
Tallow	58,856	13,301 3,771 (grease)	17,741 (including grease)	31,286
Lard	114,966	26,125	3,857 124 (compound lard)	65,318
Oleo and refined tallow	29,958	—	—	—
Oleo-margarine	—	—	11,760	12,989 7,197 (grease)
Premier jus		—	—	7,572
Beef and mutton fat, including premier jus	—	—	10,818	—

In the following table are compared the prices of tallow in the United Kingdom and New York during 1913 and 1922, together with approximate recent prices, and also prices of lard in Chicago.

AVERAGE MONTHLY PRICES PLATE TALLOW C.I.F. LIVERPOOL.

	1913.		1922.		1924.	
	Beef.	*Mutton.*	*Beef.*	*Mutton.*	*March 15th.*	
	s. d.	s. d.	s. d.	s. d.		s. d.
From (per cwt.) ..	34 0	34 6	37 3	37 0	Beef ..	44 0
To ,, ..	36 9	37 0	38 6	39 0	Mutton	45 0

LONDON TALLOW PRICES.

	s. d.	s. d.	s. d.	s. d.		s. d.
From (per cwt.) ..	35 0	36 0	37 9	37 8	up to	45 9*
To ,, ..	38 0	40 0	42 6	41 0	,,	49 0†

* Fine quality plate tallow, for shipment.

† Fine quality Australian beef tallow (home-melted tallow, 41s. to 47s., delivered, according to quality).

NORTH AMERICAN TALLOW IN NEW YORK.

	1913.	1922.	1924.
From (cents per lb.)	6½	5¾	8
To " "	7¾	7¾	(March 1).

AVERAGE MONTHLY PRICES OF PRIME STEAM LARD IN CHICAGO.

From (cents per lb.)	9·76	9·16	11·0
To " "	11·60	11·50	(February 9).
Average	10·60	10·85	

FISH AND MARINE ANIMAL OILS

As fish and marine animal oils are, to some extent, alike in character and are manufactured under similar conditions and by similar methods, it is convenient to deal with both together. Although whaling and the manufacture of whale oil have been carried out for many centuries, the use of fish as a source of oil has only become of great commercial importance during comparatively recent times. The modern production of fish oils has resulted from such causes as the necessity for utilizing surplus edible fish and waste material from canning and curing fish, for disposing of various kinds of fish unsuitable for consumption, and the obvious advantage of removing oil and water from fish and producing a material which can be kept without deterioration and which forms a valuable manure, and also a food for poultry and livestock.

Generally those fish having livers rich in oil, such as the cod (the liver of which contains about 50 per cent. of oil), have flesh almost free from oil, while fish having oily flesh, such as the various members of the herring family, do not contain much oil in the livers.

FISH-LIVER OILS.

Of the commercial fish-liver oils, cod-liver oil is the most important, but liver oils are produced from several other fish, such as skate, dog-fish, and sharks, and a good deal of liver oil from mixed livers of various fishes is sold as "coast cod oil."

Cod-liver oil is produced in very large quantities in Norway (where the Lofoten Islands and Finmarken are the principal centres of the industry) and in Newfoundland. The early method of preparing oil by allowing the livers—piled up in heaps or in barrels—to decompose is now obsolete or practically so, and the oil is now produced by heating and steaming the livers in tin-lined vessels; in some cases oil is actually produced on the trawlers at sea, but most of the oil is produced in factories on shore. In the production of medicinal cod-liver oil precautions are taken to use only fresh, undamaged, and healthy livers, and great care is taken in the production of the oil and in subsequent purification.

Manufacture of oil for technical purposes does not, of course, entail such elaborate care, but is, nevertheless, carried out in Norway and in Newfoundland

in modern plant and on very efficient lines. In the latter country the production of cod-liver oil has been for some years carried out under the supervision of the Department of Marine and Fisheries.

The reason for the medicinal value of cod-liver oil was for many years a doubtful question—a question, indeed, which has given rise to a good deal of research and much controversy; this question has now been definitely settled by the discovery of the vitamins or accessory food substances, the discovery of which is, undoubtedly, one of the most—if not the most—important in recent years in the science of bio-chemistry. Space will not allow more than the above passing reference to vitamins, but it is of interest to note that the cod-liver oil manufactured in Newfoundland is now proved to be of high and consistently constant vitamin potency.* This fact is a matter of distinct importance to British trade, as Norway has for many years held the field for medicinal cod-liver oil, leaving an outlet for Newfoundland oil only for technical purposes. Although the demand for medicinal cod-liver oil is, to a certain extent, limited, there is no reason why Newfoundland should not supply or help to supply this demand.

Some idea of the magnitude of the production of cod-liver oil can be obtained from the following figures:

PRODUCTION OF COD-LIVER OIL.

NORWAY.†

1921	1,262,536 gallons.
1922	1,774,886 „

NEWFOUNDLAND (1921-22).‡

Exports to—	*Cod Oil.* (*Tons*).	*Cod Stearine* (*Lbs.*).	*Refined Oil* (*Gallons*).
United Kingdom	784	49,558	11,177
Canada	220	—	12,438
United States of America	4,829	62,569	23,112
Other countries	4	—	1,832
Total	5,837	112,127	48,559
Value	$594,096	$3,629	$28,265

FISH OILS.

The production of fish oils of various kinds is considerable, the most important commercially being those derived from the herring (*Clupea harengus*) and the menhaden (*Brevoortia tyrannus*). Herring oil is manufactured largely in Norway and Sweden, while " fish oil " from another species of herring (*Clupea pallasi*) and from other fish is also produced in Japan. Menhaden oil is produced from fish caught in enormous quantities off the Eastern coasts of the United States of America. Fish oil is also a product of the sardine and other fisheries of Europe, while in India the Madras Fisheries Department has given a good deal of attention

* S. S. Zilva and J. C. Drummond, *Journ. Soc. Chem. Ind.*, 1923, **43**, 185 T.
† *Report Overseas Trade Dept.* ‡ *Newfoundland Customs Returns*, 1921-22.

to the production of oil from the sardine fishery at Cannanore. Pilchard oil is produced in the Cornish fisheries. Salmon oil forms a by-product of the salmon-canneries of British Columbia.

Since 1909 the production of fish oil and manure on the Madras coast has developed very considerably;* in 1920-21 there were over 600 small establishments along some 250 miles of the Malabar and South Kanara coasts, and in 1919-20 over 20,000 tons of manure were produced, most of which was exported.

The fish utilized is a species of sardine (*Clupea longiceps*). In most cases the plant used consists of small iron boiling pots heated by fire and holding only about 1 ton of fish, together with hand presses for pressing out the oil, and naturally the quality of oil is liable to be low, but the Fisheries Department is encouraging better methods, such as will result in the production of good oil. The Government plant at Tanur utilizes simple but more efficient plant, such as steam-heated pans. The oil produced appears to be all consumed in India.

The process of manufacture of oil and manure from fish is essentially a simple one, consisting in cooking the fish so as to soften the tissues, followed by pressing—to remove oil and water—and drying of the residue. The cooking may be carried out by steaming batches of fish in open vessels—of up to 5 or 6 tons capacity—with false bottoms, but in modern large-scale factories cooking is generally done by steaming in a long iron cylinder with a screw conveyer; such apparatus cooks the fish very rapidly and has the advantage of operating continuously.

The cooked fish is then pressed in hydraulic or screw presses in the older factories; in more modern factories continuous presses of the expeller type (see p. 25) are used and appear to give a drier and less oily product than hydraulic presses. The water and oil pressed out are run into tanks and allowed to separate; any finely divided fish ("gurry") is separated and pressed to remove oil. The aqueous liquid is either evaporated and the residue added to the manure, or is worked up for fish glue by clarification with alum, followed by evaporation *in vacuo*.

The cake or "green scrap" from which the oil and water have been expressed usually contains about 50 per cent. of water and 6 to 9 per cent. of oil, and would putrify rapidly; in order to prevent this it is either dried or treated with sulphuric acid.

Drying is carried out in steam driers (especially when the material is to be used for cattle food) or by means of flue gases in continuous rotary driers.

Acidulated scrap is either dried or used in the wet state for admixture with other fertilizers

WHALE OIL.

Curiously enough, whaling† is an industry of considerable antiquity. The demand for whale oil for lighting, lubricating, and other purposes was formerly so great and whaling was carried on to such an extent that some species of whale

* *Bull. No.* 13, 1921, *Madras Fisheries Dept.*

† The existing literature relating to fish oils and to whales, whaling, and the production of whale oil is scattered, not very copious, and not readily accessible, but readers will find a concise general article in the *Bulletin of the Imperial Institute*, 1914, **12**, 251, and much may be learned about the numerous species of whale by a visit to the Natural History Museum, South Kensington.

were nearly exterminated; later, the use of vegetable and mineral oils caused a great diminution in the demand for whale oils, and a consequent decrease in whaling.

In recent times the demand for whale oil has increased for various reasons, the chief of which is, perhaps, the power of converting whale oil into a colourless, odourless, hard fat, suitable for soap and candle manufacture, and for edible purposes, afforded by the process of hydrogenation.

The discovery of new whaling "grounds," and the employment of safer and more effective modern methods of whaling, initiated by the introduction in 1865 of gun-fired harpoons, have caused a considerable increase in the whaling industry in recent years.

In modern whaling the whale is approached by the whaling vessel—generally a small steam or motor driven vessel—and is shot by means of a bomb-harpoon fired from the bows of the vessel; the bomb carries an explosive charge and the harpoon shaft is fitted with expanding barbs. When the whale has been struck and becomes exhausted it is lanced to death and towed to the shore station for treatment. Such methods have rendered comparatively safe the killing of the more active and dangerous whales, such as the rorqual or finback whales.

The whales are divided into two groups: (*a*) Those bearing whalebones—Mystacoceti; (*b*) toothed whales—Odontoceti.

The first group includes the so-called "right" whales. The Greenland or Arctic right whale (*Balæna mysticetus*) yields the longest and most valuable whalebone and is now extremely scarce, though other species of *Balæna* are still caught frequently. The finback or rorqual whales (*Balænoptera* species) are the most important modern sources of whale oil.

In the second group the most characteristic is the sperm or cachalot (*Physeter macrocephalus*), in the huge head of which is a cavity filled with oily "head-matter." This valuable material is baled out of the cavity and separated by freezing and pressing into a solid, spermaceti, and a liquid, sperm oil (see under "Waxes," p. 113), as is also the head-matter from the bottle-nosed whale (*Hyperoodon rostratus*). Various other whales belonging to the Odontoceti are also utilized as sources of oil.

The process of obtaining the oil is a simple one: the blubber is removed from the whale by cutting and by pulling off in strips by means of a wire rope attached to a winch; it is then cut up in small pieces in blubber-cutters and transferred by conveyers to steam-heated vessels in which the oil is boiled out. The flesh also furnishes some oil, and all the residual tissues from boiling out the oil are drained, dried, and sold as manure, as are also the bones after grinding.

Fresh whale meat is suitable for human consumption, and large amounts are used in some countries—*e.g.*, Japan—while attempts are said to have been made to can whale flesh and to use it for manufacture of meat extract.

Oils produced from the blubber of different species of whales are mixed and sold under various grades according to quality; the grades vary from clear, almost white oil, No. 0, to very dark brown, viscous, evil-smelling oil, the difference in character being due to such causes as faulty preparation and to the use of flesh as well as blubber.

The world's most important whaling station is the island of South Georgia; this is a dependency of the Falkland Islands, the Government of which controls the whaling industry in these regions. The South Georgia whaling industry* commenced about 1906, assumed important dimensions in 1908, and has remained the most important whaling station since that date. The following table shows the extent of the whaling industry in these regions:

Annual Average.	*Vessels Employed (Number).*	*Whales Caught.*	*Average Number Barrels of Oil per Whale.*	*Oil.* *Barrels.*	*Oil.* *Tons*† *(Approximate).*	*Value (£).*
1909–1914 ..	42	8,314	36·57	304,002	55,270	822,451‡
1920	43	5,247	48·84	256,252	46,600	2,748,852
1921	48	8,520	45·05	383,816	69,800	1,559,467
1921 (seal oil)	—	—	—	2,401	44	—

In 1915 the enormous demand for all oils led to an even higher output of oil—558,805 barrels—nearly 12,000 whales being caught.

Of the various companies engaged in the South Georgia whaling industry some are British, some Norwegian; practically all the hands employed are, however, Norwegians. The South Georgia whaling industry is receiving careful attention from the Government, and an extensive scheme of research has been inaugurated. Whaling is also controlled by the issue of licenses, by a "close season," and by various regulations forbidding the killing of immature whales or of whales with calves, and also enforcing the utilization of the whole carcase in order to prevent waste.

Other whaling stations within the Empire are situated in South Africa and in New Zealand. The South African whaling stations are in Natal at Durban, and also in the Cape Province at Hoedjes, Saldanha and Salamander Bays. In 1921 the Natal whaling industry was carried on by three firms employing seventeen vessels and over 700 men; 1,071 whales were killed, and the production of oil, etc., was as follows:§

	Tons.	*Value (£).*
Oil	6,255	154,535
Whalebone	½	350
Fertilizer	2,447	24,647
Boiled bone	1,045	8,434
Finners	27	834

In 1919 and 1920 the following quantities of whale oil and other products were obtained in the Cape Province:‖

* *Report Interdepartmental Committee on Research and Development in Dependencies of Falkland Islands*, 1920, Cmd. 657

† Assuming 5·5 barrels to 1 ton.

‡ These values are conventional customs valuations only. Value of oil in Europe decreased about 60 per cent. in 1921.

§ *S. Afr. Journ. Industries*, 1922, **5**, 404.

‖ H. J. Van den Byl and J. D. Gilchrist, *S. Afr. Journ. Industries*, 1923, **6**, 510.

		1919.	1920.
Whales killed		584	660
Whale oil	Gallons	453,546	1,739,255
	Tons	1,860	7,160
	Value (£)	52,093	233,079
Manure	Tons	1,345	2,035
	Value (£)	18,228	22,720
Whalebone	Tons	41	14
	Value (£)	4,713	524
" Residue "	Tons	148	438
	Value (£)	4,725	3,365

In 1919 more than five-sixths of the manure and over half the " residue " was shipped to Mauritius; in 1920 a little over one-half the manure was shipped to the United Kingdom, and over one-third to Mauritius. In both these years the bulk of the whale oil was shipped to the United Kingdom.

According to a recent article on the whaling industry of South Africa, only four whaling stations were in operation during 1922, when the following amounts of oil were produced:

	Whale Oil (Barrels).	
Cape Province (about)	15,000	
Saldanha Bay	19,655	
Natal Province	22,500	
" "	3,700	
Total	60,855	11,060 tons.

In 1922, 16,620 tons of whale oil, valued at £447,833, were exported from Cape Town.

The authors of the article mentioned above point out that, in spite of legislation, there is really very little control of whaling off the South African coast, and they consider that steps should be taken to prevent damage to the industry which is likely to occur from indiscriminate whaling, regardless of season, size, or number of whales killed. The authors quote, in support of their advice, the fact that sealing on the South African coast was formerly carried on indiscriminately to such an extent that the industry became practically valueless, but that since it has been controlled by the Government sealing now affords a large and steady revenue.

The whaling industry connected with New Zealand is of minor importance, and only two or three stations have been in operation in recent years. In 1921-22 stations at North Auckland dealt with forty whales and produced 181 tons of oil and 40 tons of bone dust (value £8,000); at Marlborough 181 tons of oil were produced (value £4,063).*

The exports of whale oil from New Zealand (to Australia) amounted to only 22,365 gallons (under 100 tons) in 1922.†

In 1912-13 a number of samples of seal, sea-leopard, and penguin oils were obtained in Adelie Land by the Australasian Antarctic Expedition; these were

* *New Zealand Year Book*, 1923 † *Blue Book*, 1922

examined later at the Imperial Institute* and found to compare favourably in most cases with commercial blubber oils, and it is possible that the Antarctic regions may become in the future a commercial source of such oils.

Whaling is also carried on around the Faroe Islands and Iceland, off the shores of Norway, and to a small extent off the Shetlands and Hebrides and west of Ireland. The whaling industry is of some importance in Japan, the Azores, Argentina, and Chile (see Part II.; United Kingdom's statistics). In 1912-13, 1,107 whales were killed and worked up in the four whaling stations in British Columbia, and a station was also in operation at Seven Islands in the Gulf of St. Lawrence, Quebec. The total export of whale oil from Canada in 1912 was 2,422,845 gallons, in 1913 1,618,327 gallons. In the United States the whaling station at Tyee, Alaska, produced 250,200 gallons of oil in 1911.

The world's annual production† of whale and fish oils has varied from 76,400 barrels in 1906 to 805,000 barrels in 1913; in 1922, 653,000 barrels were produced, equivalent to about 118,000 tons.

It is practically impossible to arrive at details of the Empire's production and requirement of fish and allied oils on account of the fact that these oils are not generally specified separately in the various statistics. The previous figures for whale oil show that this is principally produced within the Empire, though largely by non-British labour, while cod-liver oil is also an important product in Newfoundland. Fish oil in some quantity is also produced in the United Kingdom at various fishing ports.

Fish and allied oils are generally of low price compared with other oils, but a good demand exists for such oils, at any rate for those of good quality. Some indication of demand is evident from the importation of over 16,000 tons by the United States of America in 1922, when it is considered that very large quantities of menhaden oil are produced on the Eastern American coast.

No attempt has been made here to give detailed figures relating to fish meal and fertilizer produced as a result of the production of fish and whale oils, but owing to the enormous and increasing demand for fertilizers of all kinds all over the world there is no difficulty of disposing of such material.

The chief demand for these oils within the Empire is that of the United Kingdom (see Part II.). France, Germany, Holland, and the United States are all important consumers.

IMPORTS, 1922 (TONS).

United Kingdom ..	Whale oil	28,387
	Fish oils	4,892
France	Whale oil	589
	Fish oils	6,873
Germany	Whale and fish oils	62,621
Holland	Whale oil	15,872
United States of America	Whale oil	16,674
	Cod and cod-liver oils	6,058

The higher grade oils are undoubtedly suitable for the production of hardened edible oil, as they may be completely deodorized. Against the use of high-grade

* *Bull. Impl. Inst.*, 1818, **16**, 140.

† *Review Oil and Fat Markets*, Thornett and Fehr.

whale oil for this purpose there can be no valid objections, as such oil must of necessity be prepared from fresh material by efficient and cleanly methods, not differing appreciably from those employed in the manufacture of other edible animal fats such as lard.

Various species of seals and sea-lions also yield considerable amounts of oil from the blubber, and porpoises and dolphins also yield oil.

A large bulk of the fish liver, fish, and marine animal oils appearing in commerce finds a market in the leather industry for leather-dressing and currying and also for the manufacture of chamois or " wash " leather; large quantities are also employed in " batching " jute and other fibres.

Whale oils are also used to some extent for illuminating and lubricating, and both whale and fish oils are hardened for use in soap and candle manufacture.

The price of whale oil varies, of course, with the grade. No. 0/1 was sold in the United Kingdom during 1913 at from £21 to £22 10s. per ton, and in 1922 at £30 10s. to £35 10s. The following are prices in January, 1924, for various fish and marine animal oils:

Oil.	*Market.*	*Per Cwt. in Barrels Ex Wharf.* s.	d.		s.	d.
Whale, " filtered pale " ..		36	6	to	40	0
,, " filtered brown "		34	0	,,	35	0
Sperm oil, " refined Southern "		32	0	,,	34	0
Cod, " English coast " ..		35	9	,,		
Seal oil, " filtered "		32	6	,,	38	0
Whale, " Crude No. 1 " ..	Glasgow	36	6			
,, " Crude No. 2 ".	,,	33	6			
,, " Crude No. 3 " ..	,,	31	6			
,, " Crude No. 4 " ..		30	0			
Herring, " dark to brown "	,,	23	0	,,	28	0
Cod, " coast " ..	,,	32	0	,,	34	0
,, " Newfoundland "		43	0			

WAXES

GENERAL CLASSIFICATION, SOURCES, AND USES

THE term wax is applied somewhat loosely to a variety of products of similar appearance and physical character, but differing somewhat widely in chemical nature and in origin.

Speaking broadly, the waxes of vegetable origin (*e.g.*, carnauba wax), of insect origin (*e.g.*, beeswax), and of animal origin (*e.g.*, spermaceti) consistlargely of esters of the alcohols of high molecular weight with the higher fatty acids, while oils and fats are esters consisting of glycerol combined with fatty acid.

Beeswax, for example, consists largely of myricin, the palmitic acid ester of melissyl alcohol; carnauba wax, of myricyl cerotate; and spermaceti is composed chiefly of cetyl palmitate. The term wax is also applied to various products of mineral origin—such as paraffin wax (derived from petroleum and composed of hydrocarbons) and montan wax (derived from lignite and composed largely of fatty acids)—with which it is not proposed to deal in the present volume.

The value of waxes in various branches of technology depends rather on their physical properties than on their chemical characters, their power of being readily moulded when softened by heat and of furnishing a brilliant polish being important features.

Waxes are used largely in the manufacture of polishes for wood, leather, floorcloth, etc., in various compounds for electrical insulation, and for candle manufacture.

VEGETABLE WAXES

Waxes occur in a number of plants, generally as a thin coating on the surface of the leaves or stems of plants growing in dry, hot climates. The only vegetable waxes of appreciable commercial importance are carnauba wax and candelilla wax, though sugar-cane wax has been produced on a commercial scale in recent years, and several other vegetable waxes, such as raphia wax, esparto wax, have been made in small quantities and investigated. Vegetable waxes, with the exception of sugar-cane wax, are not produced in any part of the British Empire.

Carnauba Wax.

This is obtained from the leaves of a South American palm (*Copernicia cerifera*), and is the most important commercial vegetable wax. It occurs as a thin coating on the leaves; these are cut before they are fully opened and dried in the sun, after which the wax is scraped and brushed off, melted over boiling water, and cast in blocks. Carnauba wax is particularly valuable on account of its high melting-point and brilliant polish, and is used in candles, polishes, paper varnishes, phonograph records, and electric cable coverings. It is shipped from Brazilian ports such as Pernambuco and Ceara, chiefly to the United States of America and the United Kingdom and to Germany. The exports of carnauba wax are on a considerable scale; in 1913 about 3,807 tons, in 1919 6,171 tons were exported from Brazil.

Attempts have been made in the past to induce planters in other countries to take up the growing of the carnauba palm, but these do not appear yet to have led to any definite results. Experimental cultivation in Ceylon have given satisfactory results, and it is said that production of wax will commence shortly.*

Various commercial grades of the wax (differing in colour, appearance, and freedom from impurity), such as " yellow prima," " grey fatty," " grey chalky," as well as bleached yellow wax, appear on the market.

Another palm, *Ceroxylon andicola*, which occurs in certain parts of South or Central America—*e.g.*, Colombia†—yields a very similar wax, but does not appear to be exploited commercially on any appreciable scale.

Prices of carnauba wax, London, March, 1924, per hundredweight, yellow prime, £11; grey fatty, £6 5s.; chalky, £6.

* *Oil and Colour Trades Journal*, 1924, **65**, 662.
† *Bull. Impl. Inst.*, 1917, **15**, 182.

Sugar-Cane Wax.

The refuse filter-press-cake obtained in cane sugar manufacture contain a hard wax derived from the surface of the cane. The press-cake contains wax varying from as little as 2 per cent. to as much as 17 per cent.; according to Clacher,* in Natal the dry press-cake generally contains about 14 per cent. of wax, which is more than is found in the press-cake in most other sugar-growing countries.

The extraction of this wax from the press-cake by means of solvents has been carried out on a commercial scale for some years past—for example, in Natal—and wax has appeared on the European markets.

Cape Berry Wax.

This " wax " is derived from the fruits of various species of *Myrica* (myrtles) in South Africa, and has been produced and exported in small quantities in the past.

In recent years no interest seems to have been taken in this material—*e.g.*, in 1922 there was no export, in 1921 only 150 pounds. It is really a hard fat, not a true wax; it would undoubtedly sell readily if placed on the market in quantity in good condition.

Candelilla Wax.

This wax is obtained from plants of the Natural Order Euphorbiaceæ (*Pedilanthus pavonis* and *Euphorbia antisyphilitica*), growing in Northern Mexico and Southern Texas. In recent years fairly considerable quantities of this wax have been produced by steaming the shrubs or even by extraction with solvents. It is a hard brittle wax, resembling carnauba wax in many respects, and is used in America and also in Europe for similar purposes to those for which carnauba wax is employed.

Other Vegetable Waxes.

Attention has been called from time to time to various other waxes of vegetable origin, the leaves of the raphia palm (*Raphia Ruffia*), the source of gardeners' " bass," are coated with a wax similar to carnauba wax,† but the cost of production of the wax is probably too high to allow of its commercial exploitation.

An Australian plant, the " cane " or " bamboo " grass, *Glyceria ramigera*, has been shown‡ recently to afford a similar wax, while attempts have been made to recover wax from the waste liquors obtained in converting esparto grass (*Stipa tenacissima*) into paper pulp.

* *Interni. Sugar Journal*, 1916, **18**, 23.
† *Bull. Economique de Madagascar*, 1906, **6**, 48.
‡ *Journ. Soc. Chem. Ind.*, 1922, **41**, 372 T.

INSECT WAXES

Beeswax.

Beeswax is derived from the comb of various species of bee, either wild or domesticated. In the modern methods of bee-keeping as carried out in most civilized countries production of wax is small, as the object is to produce as much honey as possible; for this purpose box-hives are used from which the full comb is removed, and the honey separated by a kind of centrifugal machine, the empty comb being then returned to the hive, while a good deal of honey is also sold in the comb.

The demand for beeswax is, therefore, met chiefly by supplies obtained from wild or semi-wild bees in tropical countries. Fairly large supplies of beeswax are exported from various parts of the British Empire, particularly the African Colonies and India. In Uganda bee-keeping and production of wax have been encouraged, and native instructors are employed, with excellent results.

The methods of obtaining beeswax from comb are very simple and can be carried out readily by natives once the necessity of observing certain details is recognized. The process consists essentially in removing honey from the comb by draining or even by squeezing by hand, the comb is then melted at a low temperature, when impurities such as dead bees, "brood" (cocoons), are easily removed by straining the wax.

A simple means of melting the wax which is commonly employed in several countries is by means of a "solar wax extractor"; this is a wooden box with a double glazed lid—somewhat resembling a garden frame for raising delicate plants and seedlings—the comb is placed inside on a sloping metal tray provided with a gauze strainer; on exposure to the sun the wax readily melts and runs into a vessel below the tray, by this means wax of excellent quality is easily prepared.

Another simple method consists in melting the comb in hot water, when the melted wax rises to the surface and any honey is dissolved. The wax is then allowed to cool and solidify, when the solid impurities which are on the under surface can be scraped off and the bulk of the wax purified further, if necessary, by remelting over water and straining. When "brood" comb, containing cocoons, is treated the comb should soak for about twenty-four hours in order that the fibrous cocoons may be thoroughly wetted and so rendered incapable of absorbing the melted wax.

There are several obvious variants of these simple processes, such as placing the comb in a canvas bag under hot water, or pressing out the wax from the comb in a steam or hot-water heated screw-press, but anyone with a little ingenuity can improvise a satisfactory method adapted to local needs and available materials. The great point to keep in mind is to melt the wax at a comparatively low temperature, and never to melt by direct heating in a vessel over a fire, but always in a vessel with water; this latter point is not always emphasized in instructions on rendering beeswax, but it is well known to those engaged in beeswax refining, and the authors can testify from their own experience, how easily the colour of pale beeswax is darkened by "dry" melting, even when such melting is done at low temperature in perfectly clean vessels.

The melted purified wax is finally poured into moulds and allowed to set.

Some little space has been expended in giving even the above brief sketch of the preparation of beeswax, but beeswax is a valuable product for which there is generally a good demand, and its production is a minor industry eminently suited for native labour in many parts of the British Empire.

Unfortunately, civilization has distributed widely such products as paraffin wax, stearic acid (in the form of candles), and rosin, and these are all liable to used as adulterants of native prepared wax. In some countries—notably India—adulteration of beeswax either by native producers or by middlemen is common, and every effort should be made to prevent such adulteration, particularly in countries where efforts are being made to foster and increase the production of beeswax. Indian* and certain other colonial beeswaxes differ somewhat in character from European beeswax.

Beeswax is employed largely in the manufacture of various kinds of polishes for leather, wood, and other materials, and is also employed in candle manufacture, though paraffin wax candles have largely replaced beeswax candles except for use in church ritual.

Decolorization or bleaching of beeswax, in order to produce white or pale coloured wax, may be effected, in many cases, by exposing thin shavings of the wax to air and light, but some kinds of wax require more drastic treatment by chemical bleaching agents.

Prices of beeswax in February, 1924, were as follows: Jamaica, £7 10s. to £7 15s.; Madagascar, £4 15s. to £5; Mogador, £4 15s. to £4 18s.; East Indian yellow-white, £4 to £4 10s.—per hundredweight.

Insect Wax.

This is produced by *Coccus ceriferus* Fabr. or *Coccus pela* Westwood, an insect which is propagated in Western China in a somewhat similar manner to that employed with the lac insect in India. Trees of a species of ash are inoculated with the insects, which are found on another species of tree in a district some 200 miles from that in which the wax is actually produced. About three months after inoculation the branches are covered by a layer of wax about ¼ inch thick; these branches are collected, the majority of the wax is removed by hand and the remainder by boiling with water. Although produced in large quantities in China it is largely consumed in China and Japan for candles and polishes and for sizing paper and fabrics, and is not exported to Europe in any quantity. It is a true wax (not a hard fat) consisting largely of ceryl cerotate ($C_{26}H_{53}.C_{26}H_{51}O_2$).

ANIMAL WAXES

Spermaceti and Sperm Oil.

Spermaceti is a hard wax and consists very largely of cetin—*i.e.*, cetyl palmitate; it occurs largely in the head-matter of the sperm whale (*Physeter macrocephalus*). Cetin is also present in the head-matter of the bottle-nose whale (*Hyper-*

* *Analyst*, 1922, **47**, 246; *Bull. Impl. Inst.*, 1922, **20**, 155.

oodon rostratus), and in dolphin and shark-liver oils. It appears to be the general custom to mix the head-matter and the blubber oil of the sperm whale and to remove the spermaceti by freezing and pressing, the liquid portion being sperm oil and the solid spermaceti. The crude spermaceti is purified by melting and boiling with dilute caustic soda solution. Spermaceti is a hard, white lustrous wax, and is employed in candle manufacture and in cosmetics.

Sperm oil must be regarded as a liquid wax, and not a fatty oil, as it does not consist of fatty acid esters of glycerol (glycerides), but of esters of fatty acids with other alcohols; the exact nature of these alcohols is not yet known thoroughly. Several grades of sperm oil are made, such as "winter sperm oil," "spring sperm oil," and "taut pressed oil," differing chiefly in the temperatue at which they congeal according to the pressure and temperature employed in removing the spermaceti. Sperm oil is a valuable lubricant for spindles and light machinery, as it does not "gum," and also because its viscosity is not greatly affected by temperature.

RESINS

CLASSIFICATION, SOURCES, AND USES

THE various resins of commerce are exudations from trees—shellac, an insect product, being an important exception. The constituents of resins are very varied and belong to many different classes of chemical compounds, which are, in some cases, comparatively little known owing to the great difficulties in separating them and obtaining them in pure condition. The chemistry of resins cannot be discussed here. A summary of this subject will be found in J. J. Morrell's *Varnishes and their Components*, 1923. Commercial resins are often popularly termed "gums" or "varnish gums," owing to the fact that they outwardly resemble gums in appearance. This looseness of nomenclature is to be deplored, as resins are entirely different in behaviour and character from the true gums, and a few simple tests serve readily to differentiate them.

True gums either dissolve in water and form a viscous liquid, or swell up and form a jelly: resins are insoluble in water; and when held in a flame resins melt and burn readily, while gums char and give off a smell like that of burnt sugar. Gums are insoluble in alcohol or spirit of turpentine, while resins are soluble or partially soluble. Resinous exudations from trees are sometimes wholly or almost wholly resinous; in other cases they are oleo-resins or mixtures of resin and volatile oil—*e.g.*, the oleo-resin from pine trees—the source of rosin and turpentine (see p. 115); and in others oleo-gum-resins containing resin, gum, and volatile oil—*e.g.*, myrrh.

A resin should give a brilliant coating when applied to a smooth surface in solution in some volatile solvent such as turpentine or alcohol. This coating should dry rapidly, and when dry must be smooth, transparent, and hard, and must not deteriorate appreciably on exposure to air and light. The more nearly colourless the resin is the better, and the varnish made with it should not discolour

with age. The chemical character of the resin is also a matter of importance—for example, colophony or rosin is largely composed of organic acids, and its uses in certain directions are thereby limited; roughly speaking, inertness in the chemical sense is one of the chief essentials of a resin.

Resins are chiefly employed in the manufacture of varnishes, enamel paints, and lacquers. Varnishes consist of solutions of resins in some volatile solvent (chiefly turpentine); oil varnishes contain drying oils such as linseed oil as well; while enamel paints are made by mixing pigments with drying oils together with resin to impart brilliance to the surface. Lacquer is the term generally employed in connection with spirit varnishes made by dissolving shellac in alcohol, but the term is loosely applied to other preparations. Resins—*e.g.*, kauri copal—are also employed in the manufacture of linoleum, while rosin is largely used for the manufacture of rosin soap (a common ingredient of cheap soaps), and also for sizing paper; shellac is largely used in the manufacture of gramophone records. Various resins—particularly the cheaper kinds, such as rosin—find uses in different minor manufactures.

The chief resins of technical importance are colophony or rosin, shellac, copal (including "kauri"), and dammar, while sandarac, acaroid, mastic, benzoin, are of minor importance; oleo-resins, such as elemi, Venice turpentine, and Canada balsam, are also used to some extent (generally to aid in the solution of hard resins and to impart flexibility to the varnish film). Resinous products, such as dragon's blood and gamboge, are only of importance as colouring agents, while such materials as myrrh and frankincense are only used in pharmacy or on account of their pleasant odour in perfumes or in making incense.

The commercial resins are, in some cases, recent exudations from living trees; in other cases—*e.g.*, certain kinds of copal—they are "fossil" resins dug up from the soil and produced by trees no longer existent; the "fossil" resins furnish harder and more durable varnishes than resins from living trees (see "Kauri"), and are consequently much more valuable.

ROSIN AND TURPENTINE

Rosin is produced from the exudation obtained by "tapping" or "bleeding" various species of pine trees. The exudation (commonly termed "gum" in America, "gemme" in France) is an oleo-resin—*i.e.*, a mixture of resin and volatile oil—and is separated by distillation into its two constituents, the resin (commonly called rosin or colophony) and turpentine.

Although turpentine is a volatile oil, and therefore does not fall within the scope of the present volume, it is proposed to deal with it here, because both rosin and turpentine are produced from the same source and in the same process, and also because turpentine is a material of considerable importance to certain users of oils—viz., manufacturers of paints and varnishes. Further reference to turpentine will also be found in Volumes VI. and VII. of this Series.

The "bleeding" of pine trees for "gum" is undoubtedly an industry of considerable antiquity, the crude "gum" or tar or pitch produced from it

having been used for caulking ships. An early reference is to be found in a manuscript dealing with products obtainable from Virginia in 1610; turpentine and rosin are recorded to have been made in North Carolina in 1783, while pitch and tar had been produced since 1700.

The world's supplies of turpentine are chiefly obtained from the more southerly parts of the United States of America and France, America producing about 75 per cent. of the total, while the greater part of the remainder is obtained from the coastal regions of south-western France.

In America the chief source of turpentine and rosin is the southern long-leaf pine (*Pinus palustris*), while the Cuban or "slash" pine (*P. caribbea* or *heterophylla*) and other species are also used; in France in the departments of Landes and Gironde turpentine is obtained from the maritime or cluster pine (*P. maritima*); in Northern Italy from the stone pine (*P. pinea*); in Greece and Algeria from the Aleppo pine (*P. halepensis*); in Austria from the black pine (*P. laricio austriaca*); in Central Germany, Poland, and North Russia from the Norway pine (Scotch fir, *P. silvestris*); in Mexico and Central America from the Mexican white pine (*P. ayacahuite*); in Japan from the Japanese black fir (*P. Thunbergii*); while in recent years in India the chir pine (*P. longifolia*) and the Himalayan or Bhotan pine (*P. excelsa*) have been worked for turpentine and rosin.

In the United States; Florida, Georgia, Louisiana, and Alabama are the most important producers.

In addition to the turpentine obtained from the "gum," a good deal of turpentine is also now obtained from stumps and fallen and dead trees by distillation, some 10 per cent. of the total turpentine produced in the United States being obtained from these sources, while a good deal of turpentine is made in this way in Russia, Finland, Norway, and Sweden.

There are two methods of obtaining the crude "gum" from the trees—viz., the Box and Cup systems. In the box system* a cavity is cut by means of an axe near the base of the tree trunk; generally the box is about 12 to 14 inches wide, 7 inches deep, and 3½ to 4 inches from back to front, and holds about 3 pints. Above this box the trunk is subjected to periodical "chipping," or removal of strips of bark and wood throughout the season; in America the season lasts from March to October or November, and the trees are chipped about thirty times. On the larger trees several boxes are generally worked. The crude gum is taken from the boxes every three or four weeks, being removed from the boxes by means of a flat trowel-shaped tool or dipper, and is collected in buckets and transferred to barrels for transport to the stills. At the end of the season the "gum," which has solidified on the chipped surface owing to partial evaporation of turpentine, is scraped off and worked up; "scrape" gives a lower yield of turpentine and a darker rosin on distillation than the "gum" dipped from the boxes.

After the fourth season the worked face of the tree generally reaches to about 8 feet, above which it does not pay to work, and a new "box" is therefore made. The crude "gum" or "dip" from the boxes usually contains about 15 per cent.

* An excellent account of the industry is to be found in "The Naval Stores Industry," *U.S. Dept. Agric. Bulletin*, 229.

of water and trash (chips) and 18·5 per cent. of turpentine. "Scrape" contains about 10 per cent. of trash and 10 per cent. of turpentine, the remainder being in both cases rosin.

Owing to the fact that the box system has many disadvantages, such as damage to the tree, loss of "gum," and danger of fire, the use of cups made of metal or clay, together with gutters or aprons to guide the flow of "gum," was introduced into France many years ago, and has now almost entirely superseded the box system; in the United States also cup and gutter systems have very largely replaced the box system, and experiments made in 1902 proved conclusively that the yields and qualities of both turpentine and rosin were better from cups than from boxes.

The advantage of the cup system is that the cups can be easily moved up the tree, so that as chipping of the face rises the "gum" need not flow so far as in the box system, consequently the cup system gives less "scrape" than the box system.

The distillation of the crude "gum" is generally carried out on very simple lines. Large fire-heated copper stills, 500 to 1,000 gallons capacity, are used, connected to a water-cooled copper coil-condenser; the gum is heated carefully in the still to avoid frothing, a thin stream of water being admitted during distillation to supply the necessary steam. The yield of turpentine is from 16 to 22 per cent. of the original weight of dipped "gum" treated. The turpentine passes over with the water and separates on standing; it is then poured directly into 50-gallon barrels. The rosin remaining in the still is drawn off at the end of the run; and in order to separate chips of wood and other solid impurities. the melted rosin is strained through screens, the last of which is covered with cotton batting, and is finally run into barrels holding about 450 pounds.

At times when rosin has fetched a high price, it has been extracted by solvents from the chips and other resinous material obtained from the stills.

In some countries—*e.g.*, in France—the crude "gum" is often subjected to processes of purification before distillation. The "gum" is heated carefully in open—or preferably in closed—pans until liquefied; bark and chips are removed by skimming and straining, and the clear melted gum removed from any dark-coloured water and sand at the bottom of the pan. In this way a rosin of higher grade is obtained than would be possible by direct distillation of the untreated "gum" containing bark, etc.

A certain number of steam-heated stills are employed—in France, for example—and these are undoubtedly capable of giving turpentine and rosin of better quality than the simple direct-heated stills; the steam-heated stills are, however, more costly to instal and to operate.

Freshly distilled turpentine consists of various closely related unsaturated hydrocarbons known as terpenes ($C_{10}H_{16}$), together with small amounts of oxidized substances derived from the terpenes. American turpentine generally contains 80 to 85 per cent. of α-pinene, which is dextro-rotatory; French turpentine contains lævo α-pinene; while various other terpenes have been isolated from turpentine.

Turpentine is chiefly used as a thinner in paints and varnishes, for which it

is particularly suited owing to its solvent powers, its ready volatility and capacity of absorbing oxygen.* Smaller quantities are also employed in the preparation of various wax polishes and in pharmaceutical preparations. Turpentine is also employed in the manufacture of terpineol and terpin hydrate, and forms the " raw material " in the manufacture of synthetic camphor. Various minor uses for turpentine are found in calico-printing, printing ink, sealing wax, etc.

Turpentine is carried in barrels (generally white oak) or steel drums, and frequently in railroad tank wagons in the United States of America. As turpentine readily penetrates dry wood, the barrels should be " glued "†—*i.e.*, coated internally with a thin coat of glue; when placed in iron containers discoloration is likely to be caused by the action of small quantities of acids (formed by oxidation of the turpentine) on the metal; tank cars, therefore, are usually painted inside with a shellac (in alcohol) paint. As turpentine is an expensive material (see p. 119) adulteration with light petroleum or with benzene is not at all uncommon.

Rosin or colophony is a soft transparent resin varying in colour from nearly white to very dark red-brown according to its source and the care taken in preparation. Rosin consists largely of organic acids, the chief being abietic acid, and consequently combines with bases to form soap. The soda soap prepared from rosin is largely used in the cheaper grades of soap, while several of the metallic soaps, such as those of lead, manganese, and cobalt, are largely used in paints as " driers " to increase the rate of drying of the paint.

Rosin is also largely employed in paper sizing; a rosin soap is added to the pulp in the beater and is then precipitated by adding a solution of alum; on calendering the paper on hot rollers a smooth polished surface is produced. The lime soaps are also used in the manufacture of solid lubricating greases, such as wagon grease.

Rosin is employed in the manufacture of the cheaper varnishes; prepared from untreated rosin alone, these are somewhat easily scratched and deteriorate rather rapidly. Varnishes of better quality are, however, furnished by zinc resinate or by esterified rosin or " ester gum " (*i.e.*, rosin which has been heated with glycerine to convert the free acid into the glycerol esters of the acid).

Rosin is also used in linoleum, sealing wax, brewers' pitch, printing ink, pharmaceutical preparations, and for various other minor purposes.

On distilling rosin, particularly the lower grades of dark colour, various fractions are obtained, the lower boiling fractions are employed as solvents, while the heavier fractions are used in printing inks and lubricants. Lampblack of excellent quality is made from rosin oil and used in the preparation of Indian ink and certain printing inks.

It would be almost impossible to give any useful estimate of the world's total production of turpentine and rosin, but the following figures for production

* Various substitutes for turpentine, such as readily volatile petroleum distillates (" white spirit "), are used for these purposes, and more recently hydrogenated derivatives of naphthalene, such as " tetralin," have been introduced.

† A good flexible coating is made by glue (20 lbs.), water (8 gallons), borax ($\frac{1}{4}$ lb.), glycerin ($\frac{3}{4}$ lb.).

in the United States, which produces some 75 per cent. of the total, and for France, the next important producer, are of interest:

		1910–1920. Production.	Exports.
Rosin,* barrels, 500 lbs. gross (approximately 450 lbs. net)	Maximum	2,267,000	1,470,970
	Minimum	1,237,000	501,838
Turpentine,† 50-gallon casks	Maximum	680,000	432,680
	Minimum	372,000	83,241‡

EXPORTS OF ROSIN AND TURPENTINE.

	United States of America. 1921	1922	France. 1921	1922
	(Barrels).	(Barrels).	(Metric Tons).	
Rosin	1,001,542	1,427,097	79,799	58,216
	(Gallons).	(Gallons).		
Turpentine	9,267,959	9,863,979§	12,658	12,965

The largest exports of rosin from the United States in 1921 were those to the United Kingdom, 212,692 barrels; the Argentine, 158,330 barrels; and Germany, 137,868 barrels. The largest exports of turpentine were as follows: to United Kingdom, 4,423,954 gallons; to Germany, 1,032,746 gallons; to Canada, 952,456 gallons; to Netherlands, 863,436 gallons; and to Australia, 338,177 gallons. Of the exports of rosin from France in 1922, 10,143 metric tons went to the United Kingdom, 11,678 to Germany, and 3,681 to Australia.

American rosin is graded according to colour as follows: W.W., water white; W.G., window glass from " virgin dip "; N., extra pale; M., pale; K., low pale; J., good; H., No. 1; F., good No. 2; E., No. 2; D., good strain; C., strain; B., common strain; A., black. The best French rosin (window glass or verre-à-vitre) is purified rosin bleached by exposure to light.

Prices of American rosin and turpentine in the United Kingdom were as follows in February, 1924:

Grade.	Per Cwt. s. d.	s. d.	Grade.	Per Cwt. s. d.
B/G	14 0		W.G.	18 0
H/M	15 0 to	16 0	W.W.	19 6
N	17 0		Turpentine	77 0

* Includes " wood " rosin obtained by treatment of stumps, etc.
† Includes " wood " turpentine obtained by treatment of stumps, etc.
‡ 1918–19.
§ Includes 494,576 gallons " wood " turpentine.

LAC-RESIN

Lac-resin—commonly known commercially as "shellac," though this term is strictly applicable to a special manufactured form of the resin—is the product of an insect, *Tachardia* (*Coccus*) *lacca*, produced chiefly in India, but also in Indo-China and Siam.

The insects form a resinous incrustation on the twigs and branches, which incrustation is collected and treated as described below.

In spite of the long standing and considerable importance of the Indian lac industry, the industry is "encrusted with local prejudice and handicapped by unscientific methods" (*Indian Forest Records*, 1921, **8**, Part I., "Report on Lac and Shellac," H. A. F. Lindsay and C. M. Harlow, p. x), and although a very considerable amount of valuable work from the scientific and also from the commercial standpoint has already been done, it is evident that there is still much scope for further work.

"Cultivation" of Lac.

Space will not permit any lengthy description of the cultivation, collection, and preparation of lac here; the whole subject is one full of interest from biological, botanical, and economic standpoints, and any who are interested in obtaining full information should refer to the exhaustive report mentioned above. Only a brief outline can be given in the following pages.

The lac insect belongs to the group of Coccidæ or "scale-insects"; in these insects the scale or outer covering consists of various excretions and secretions and moulted skins forming a protective covering to the insect, and in the case of the lac insect this scale is markedly thick and composed of brownish resinous matter known as lac.

The purple-coloured lac insect attaches itself to the stems and twigs of various plants, sucking the juices of the plant through its proboscis and covering itself with lac. The female insect lives for about six months, and so produces two broods each year; the summer brood hatches and the larvæ emerge in the hot weather or early rains, and the larvæ from this brood mature during the cold weather and produce the winter brood.

Two swarms a year are thus formed, yielding two crops of lac, the summer or "baisakhi" crop generally collected in June and July, and the winter or "katki" crop collected in October and November.

The trees most commonly used as host plants for the lac insect are the kusum (*Schleichera trijuga*), the ber (*Zizyphus jujuba*), the ghont (*Zizyphus xyloporus*), and the palas or dhak (*Butea frondosa*). The lac formed on the kusum tree is particularly pale and clear, and is consequently more valuable than that obtained from the other trees, while the crops of lac obtained from kusum trees are also larger than those from the other trees. Kusum lac is generally collected separately from that on other trees, and, in fact, the summer and winter crops of lac from kusum trees are known as the "jethwi" and "kusmi" crops respectively. The kusum tree, though widely distributed, is not common; it is also a slow grower, does not coppice well, and when pollarded

is less vigorous than the other species, and for these and other reasons kusum cannot be recommended for planting for the purpose of raising lac, though infection of available trees is obviously desirable.

Ber is popular as a host tree for lac, and is gradually becoming more so and replacing palas, as it is easily propagated, grows rapidly under good conditions, and coppices well. Palas trees are largely used, and ghont is also to be recommended where it is abundant.

The cultivation of lac is essentially simple and merely entails the infecting of suitably pruned trees with young lac insects, but, like many essentially simple operations, necessitates careful attention to detail and a knowledge of the scientific factors involved, which it is not possible to discuss here.

Infection of trees with lac insects is effected by attaching sticks covered with brood-lac, the larvæ of which are about to emerge, to the twigs or branches, or the sticks of brood-lac may be merely laid among the bases of pollard shoots. On hatching out from the brood-lac the young larvæ travel on to the growing shoots of the host tree and form new growths of lac which are collected when mature.

Skill is necessary to avoid over-infection, and the brood-lac is removed when infection is completed. After infection, all that the collector has to do until the crop is ready for collection is to ensure that the crop is not stolen; the high prices of lac in recent years have given rise to much trouble from thefts of stick-lac from the forests in some localities.

Generally the crop is collected by cutting or breaking off the resin-encrusted twigs before the insects have swarmed; this practice is, of course, wasteful, as the insects are destroyed. A better procedure is to leave the crop until the insects have swarmed, as the resin is not harmed by being left on the trees; in fact, the resin collected before the larvæ have hatched contains a larger amount of colouring matter which has to be removed during preparation for market. The cutting of twigs is also unnecessary and undesirable, as the resin may be broken off the twigs by twisting the twigs, and so collected almost free from twigs, etc.; this improved method has been adopted by some collectors in India with good results, though it is more laborious than the cutting of the twigs, and also leads to a certain amount of waste, due to lac adhering to the twigs.

After collection the stick-lac should be carefully dried in the shade; thorough drying is particularly desirable in the case of stick-lac collected before the insects have swarmed, as such lac is saturated with moisture and contains the living mother insects, which occupy 25 per cent. of the bulk; if such stick-lac is not dried it undergoes fermentation during transit and storage and eventually forms a solid mass of " blocky " lac which is difficult to treat, and only suitable for manufacture of low-grade shellac.

The various problems connected with the lac industry in India are obviously of great importance and have for years past received the most careful consideration from the Forest Department. Comparatively little organization exists at present in India, either in the collection or preparation of lac; collection is largely in the hands of primitive jungle tribes, who depend for their livelihood on forest products such as lac, while much of the lac produced is prepared for

market on a comparatively small scale by simple methods. An example of what may be done by organization is afforded by the results obtained by a trading concern initiated early in the War in the Central Provinces. This concern, the Eastern States of Central India Export Trust, known as "Esociet," was originally founded by the Durbars of Maihar and Nagod, and later the States of Datea, Panna, and Chhatapur also participated.

The right of collection of lac in certain forests of the Central Provinces was leased to this concern for a period of five years on a royalty basis with a sliding scale, regulated by the average monthly selling price of T.N. shellac in Calcutta. The royalty being charged on the weight of stick-lac taken from the forest as certified by the railway receipts. The "stick-lac" was worked up by the "Esociet" factory at Maihar. It appears that similar methods might well be employed when possible in other parts of India.

Manufacture of Shellac, etc.

The preparation of the resin in marketable forms from the collected material entails separation of the resin from twigs, dead insects, bark, and other impurities, and removal by washing of the colouring matter. This red colouring matter was formerly a very important article of commerce—lac-dye, the origin of the term "crimson lake"—this is still used locally to some extent, but, like other natural dyes, has been superseded by synthetic products, and is no longer exported.

The production of lac in its various commercial forms is very largely in the hands of native workers, using simple hand-worked appliances, machinery only being used by the few factories. The main steps in the treatment of lac may be summarized briefly as follows:

1. *Cleaning and grading* by hand-picking, mainly with the objects of separating clean resin suitable for high-grade shellac.

2. *Crushing* in stone mills, in corn-crushing machines or between rollers to break off the resin from sticks.

3. *Winnowing and sifting* to separate resin from sticks and dirt.

These simple processes result mainly in the production of (*a*) small broken pieces of crude lac-resin (grain-lac); (*b*) dust and waste generally used by local workers, such as makers of lac ornaments, bangles, etc.; (*c*) twigs, used as fuel.

4. *The grain-lac is washed* to remove colouring matter; this is effected by placing the grain-lac in stone pots, covering with water, and allowing to stand overnight. The material is then subjected to about three successive washings with water, removal of dye being facilitated by agitating and rubbing the grain-lac against the rough sides of the pots. The washed grain-lac is then spread out to dry.

5. *Manufacture of Shellac, etc.*—Although a certain amount of lac-resin is used and exported in the form of washed grain-lac, the majority is converted into shellac. The manufacture of the commercial forms of lac from grain-lac entails melting the resin, straining the melted resin through cloth, and forming the resin while plastic into "shellac," "button-lac," or "garnet-lac." In

order to produce definite market grades of shellac it is customary to blend different sorts of grain-lac before melting. After blending, the grain-lac is placed in cloth bags about 2 inches in diameter and 30 feet long, generally made of cotton. By heating the bag in front of a charcoal fire about 3 feet in length and applying pressure by twisting the bag, the molten lac passes through the cloth leaving insoluble impurities behind.

The purified lac-resin is then formed into "buttons" about 2½ inches in diameter by pouring on to a flat surface or into shellac by a simple but curiously ingenious process. The purified plastic resin is spread thickly on to a hollow porcelain cylinder filled with warm water, smoothed by hand, and polished with a cloth; this sheet of resin is then removed from the cylinder, seized by the worker by hands, feet, and mouth, and stretched out in front of the fire to a very thin sheet measuring 4 or 5 feet by 3 to 4 feet. This sheet is broken up when hard, forming the well-known shellac of commerce. Garnet-lac is merely the thick slab of resin from the cylinder allowed to set without stretching.

In certain grades a little yellow arsenic sulphide (orpiment) is added before melting to meet trade requirements of colour; rosin—generally 10 to 12 per cent.—is also often incorporated with the resin before melting, particularly when old or inferior stick-lac—which is difficult to melt alone—is being worked. Rosin in lac, unless excessive, can scarcely be regarded as an adulterant, as its use in lac manufacture is recognized by buyers, who include clauses in sale contracts to control the amounts of rosin.

The factories employing machinery for the treatment of lac-resin and production of shellac do not appear to be numerous and are mostly in Calcutta. A good many manufacturers employ power to drive crushing and washing machines, and steam heating is in some cases employed for melting the resin.

Extraction of lac-resin from grain-lac and other washed lac by means of solvent is also carried on in some works, alcohol being the general solvent used. Detailed information of the processes and plant employed is lacking; apparently the manufacturers regard the methods as trade secrets, though no doubt, as is so common with trade secrets, there is not much to hide. The process consists essentially in dissolving the lac in hot alcohol, filtering to remove insoluble impurities, and recovering resin and solvent by distillation.

Mechanical—particularly solvent extraction—processes are obviously advantageous, as they are rapid, save labour, and enable practically all resin to be recovered, and low grades of stick-lac and waste to be worked up. At present it appears* "doubtful whether the mechanical process can produce a shellac so suitable for all purposes as the hand-made shellac," though exactly how the two products differ is not yet certain. The chief difference seems to be that extracted lac is said to be less readily soluble—an important factor—than hand-prepared lac, while some darkening of colour is liable to take place during removal of alcohol.

There seems to be no reason why difficulties of extraction should not be overcome eventually, and the authors are in entire agreement with the statements in Lindsay and Harlow's *Report on Lac* (p. 65), to the effect that "there is

* *Loc. cit.*, p. 65.

undoubtedly a big future before the mechanical process as soon as . . . . problems can be solved. Their solution should only be a matter of time and research."

Lac is composed chiefly of resin, but also contains a proportion of wax, and although a fair amount of research work has been done on the chemical nature of lac it cannot be contended that the composition of the resin is fully understood. The resin consists of resin acids and also resin esters.

Shellac undoubtedly owes some of its intrinsic properties to the presence of wax, and it has been suggested that differences observed in the composition and behaviour of shellac prepared by different methods are due to variations in wax content.

The Uses of Lac-Resin.

In India and other countries of production lac-resin is chiefly used for the ornamentation of various materials such as wood and metal articles and for the manufacture of bangles and toys.

In the countries to which lac-resin is imported it is used for a great variety of purposes, and as many of the various industries buy lac-resin in comparatively small quantities the lac market is of a distinctly speculative nature, and prices are liable in consequence to fluctuate widely over short periods of time.

The value of lac—which is one of the most important commercial resins—in various manufactures is due largely to the fact that no equally useful substitute is known; certain other natural resins possess somewhat similar properties, but are not so easily applied as shellac, which is readily soluble in alcohol and melts at a moderate temperature.

For some years past various synthetic resins have been manufactured—(*e.g.*, the phenol-formaldehyde resins) which are capable of replacing lac-resin in certain manufactures, but it does not appear that any product has been manufactured which will entirely replace lac-resin in all its uses, or that there is any prospect in the near future of a diminution in the demand for lac-resin.

Lac-resin is largely used in the electrical industries for insulating, in the form of insulating varnish and as an insulating and binding agent in articles made of paper, and as a binding agent for insulating materials built up of mica (micanite). From 40 to 50 per cent. of the entire demand is due to the requirements of manufacturers of gramophone records, and probably no other single industry requires more than 8 per cent. of the total.

Large quantities of lac-resin are also employed in the manufacture of varnishes, polishes (*e.g.*, " French polish "), and lacquers for wood and metals. It is also employed in stiffening felt and straw in hats, and for crêpe, while the better grades of sealing wax are composed largely of lac-resin, and there are almost innumerable minor uses of shellac.

Its importance as a lacquer for metal, its employment in electrical manufactures, and various other uses, render it an important war material, the production of which must be regarded as essential. During the War it is of interest to note that shellac prices were controlled.

Wide fluctuations in the price of shellac and other forms of lac were common even before the War; thus in 1901 T.N. shellac sold at about 60s. per hundred-

weight in London, rising to 220s. at the end of 1903. Omitting the War period when shellac shipments were controlled, the wildest fluctuations have taken place in recent years. In January, 1919, T.N. shellac was at 300s. per hundredweight, but rose in February, 1920, to over 850s. per hundredweight. T.N. shellac is a recognized standard grade, which, however, varies in quality from year to year. In London such lac is bought on contract, specifying that it shall be of equal value to standard sample of T.N. and not contain more than 3 per cent. of adulterating matter, or if inferior thereto a fair allowance shall be made. It appears to be the custom of Calcutta brokers to blend pure T.N. which is free from rosin with rosinous shellac so as to produce a mixture which will comply with the London standard. In New York "ordinary pure T.N." must be free from rosin.

The following are prices of various grades of lac-resin on the London market in February, 1924:

	Per Cwt.				
	s.	d.		s.	d.
Orange, 1st marks	325	0	to	345	0
,, 2nds, good to fine	320	0	,,	330	0
T.N., fair	280	0	,,	285	0
,, March	285	0	,,	292	6
,, May	282	6	,,	290	0
Button, first pure	335	0	,,	340	0
A.C. Garnet, cakey to blockey	290	0			
G.A.L.	280	0			
,, blockey	265	0			
Seed-lac	500	0			
Stick-lac	210	0			

VARNISH RESINS

Copal.

The various kinds of copal resin which appear on the market may be roughly divided into two classes: "hard" or "fossil" copals, which are dug up from the ground and which are the product of trees which have now disappeared; and "soft" copals, produced by living trees generally by a process of tapping or wounding the bark.

The East African copal, commercially known as Zanzibar "animé" or copal, is a fossil kind, so also is much of the New Zealand and New Caledonian copal known as "kauri gum," and originally produced by the kauri pine (*Dammara australis*). Copals from the Dutch East Indies and Polynesia—"Manila copal"—are all derived from living trees, principally *Dammara orientalis;* while South American copals, such as "Demerara animé," or Brazilian and Colombian copals, are mostly the produce of living trees of *Hymenæa Courbaril*, though some fossil resin is found also.

There are various kinds of East African copal, the best of these being "Zanzibar animé"; this is the hardest known form of copal, and is a fossil resin originally produced by a species of *Trachylobium* and obtained by digging chiefly from the sandy soil of the coast belt of what was formerly known as German East Africa;

these trees also occur in Portuguese East Africa and Madagascar and are said to occur in British East Africa. Madagascar fossil copal is softer than Zanzibar copal and of darker colour; copal from living trees (*Trachylobium* species) is also obtained in Madagascar. Other East African copals are those of Mozambique and Lindi.

West African copal varies greatly in quality, the medium and poor qualities are soft and are derived from living trees; the better kinds are hard, fossil, or semi-fossil copals. Copal is obtained on the west coast of Africa from Sierra Leone to the Portuguese Congo. The botanical origin of some of the West African copals appears to be still somewhat uncertain, but it seems almost certain that Sierra Leone* copal is derived from *Copaifera Guibourtiana*, Niger copal from *Daniella oblonga*, and Gold Goast copal from *Cyanothyrsus Ogea* Harms. and *Daniella Ogea* Rolfe, or other species of *Daniella—e.g.*, *Daniella similis* Craib.

The Angola and Congo copals are probably the produce of *Copaifera Mopane* (which tree also occurs in South Africa). Red Angola copal is a fossil copal, Benguela copal varies from yellow to red in colour and is often covered with a white incrustation. Congo copal is obtained chiefly from the tributary valleys on the left bank of the Congo River, between Leopoldville and Stanleyville; a large proportion of this is fossil copal obtained by digging after locating the copal by a rod pushed into the ground (*cf.* Kauri, p. 128). Collection commences when the ground is soft from the rains, and generally goes on from February to July; it is said that a good collector may get 25 to 35 kilos (1 kilo=2·2 pounds) a day, an average being 15 to 18 kilos. Fossil copal is also obtained from river beds and recent copal by tapping living trees.

The trade in Congo copal is considerable; over 9,860,000 kilos were carried by the Congo railways in 1920 (during nine months), and the exports from the Belgian Congo amounted to 6,231 tons in 1919.

British West African Colonies producing copal are the Gold Coast, Sierra Leone,† and Southern Nigeria; supplies of fossil copal from these sources are now said to be limited,‡ though fossil copals (*e.g.*, Accra) are still met with on the market. Much of the copal is obtained by tapping living trees, and owing to wasteful methods depletion of the forests is feared; in some localities steps have been taken to prevent unsystematic tapping and to encourage planting of trees, while export of copal from Sierra Leone has been prohibited since 1920.

Resin is obtained from living trees by cutting out pieces of bark 2 or 3 inches square at intervals of about 9 inches on the trunk and larger branches. The resin exuded from the cuts is afterwards collected. Generally speaking, the better kinds of African copal are derived from the Congo, Angola, and Benguela, medium sorts from Sierra Leone and Accra, the Niger copal being generally of low grade.

"Manila" copal is the produce of *Dammara orientalis* and is so called owing to its shipment from that port (not because it is produced there). Many varieties are known varying from hard fossil resin to soft resin from living trees.

* *Colonial Reports, Miscell.*, No. 63, Cd. 4971, p. 171. *Impl. Inst. Bull.*, 1914, **12**, 217.
† See Part II.
‡ Morrell, *Varnishes and their Components*, p. 120.

Pontianaç (Borneo) is the hardest kind and is superior to Macassar copal; Java copal is superior to the Borneo sorts and is intermediate between Angola and Benguela copals in hardness. The harder Manila copals are used by oil-varnish makers, though inferior to good African copal or to kauri; the softer Manila copals are soluble in spirit. Tapping is effected by cutting long strips of the bark, commencing close to the ground, and it is said that trees may be tapped for twenty-five years and will yield 550 pounds of resin. Although some of the South American copal is fossil, even this is said to be soft and in small demand.*

The copal resins of commerce vary greatly in character and value, the hard or fossil kinds being much more valuable than those of recent origin from living trees. Most kinds of copal are not soluble or only partially soluble in such solvents as turpentine, and when employed in manufacture of varnishes are, therefore, melted or "run" and kept in a fused state for some time by heating to a fairly high temperature and until the melted resin becomes readily soluble. In this process losses take place owing to decomposition and volatilization, the amount of loss depending on the kind and grade of copal, and the care with which the melting is carried out, while the quality of the melted product is naturally influenced also by the kind of copal and the impurities present.

	£	s.	d.		£	s.	d.
West African:							
Congo (per cwt. in Liverpool, January, 1924)	20	0	0	to	30	0	0
Accra, etc. ,, ,, ,, ,,	20	0	0	,,	25	0	0
Sierra Leone (per lb. in Liverpool, January, 1924)	0	0	6½	,,	0	2	1½
East African:							
Zanzibar animé:							
Fine washed (per cwt. in London, February, 1924)	22	0	0	,,	25	0	0
Fair to good ,, ,, ,, ,,	16	0	0	,,	22	0	0
Bean and pea ,, ,, ,, ,,	11	0	0	,,	13	0	0
Ordinary and good glassy	8	10	0	,,	11	0	0
Madagascar: Fair to good palish	5	0	0	,,	6	0	0
South American:							
Demerara:							
Good (per cwt. in London, February, 1924)	5	10	7				
Low to fair ,, ,, ,, ,,	2	10	5				
Dutch East Indies:							
Manila and Macassar:							
Fair dark brown to fine pale scraped	3	5	0	to	4	13	0
Mid to fair half hard	2	10	0	,,	3	0	0
Nuts, ordinary to fine pale	1	10	0	,,	3	15	0
Chips	1	5	0	,,	2	5	0
Soft blockey	0	10	0	,,	1	10	0
Pontianac:							
Dark to pale scraped hard	6	10	0	,,	7	0	0
Unsorted to half scraped	3	15	0	,,	4	5	0
Nuts	3	10	0	,,	4	0	0
Chips	3	0	0	,,	3	10	0

Crude copal is frequently cleaned and sorted† carefully into grades before shipment; washing is desirable when the crude copal is coated with an opaque layer

* Morrell, *loc. cit.*, p. 121

† *Impl. Inst. Bull.*, 1914, **12**, p. 220.

of "weathered" material, and may be effected by allowing the copal broken into rough cubes of 1 to 1½ inches—to soak for about twenty-four hours in dilute (say ½ per cent.) caustic soda solution, after which it is washed and dirt, etc., removed by brushing and scraping; the dried material is then carefully sorted by hand according to colour.

A particular grade should be uniform in colour and fairly uniform in size, the palest transparent material being the most valuable; dust and chips should be sold separately as lower grades. Colour, size, hardness, and freedom from impurities are the chief factors to be considered in grading resins such as copal. The fine grades of copal for varnish-making are largely valued by their appearance and general character; low grades of "kauri," such as dust and chips, used for linoleum, by analysis (per cent. of dirt and resins).

The prices of copal vary very greatly according to the quality; the figures on p. 127 of recent prices will serve to indicate the value of some of the better-known grades.

Kauri Gum.

Kauri copal, or kauri "gum," as it is generally termed, is an important resin of which large quantities have been exported annually from New Zealand; for the period 1910-20 the annual export of kauri "gum" amounted to about 5,380 tons of an approximate value of £340,000, and in 1922, 6,391 tons, valued at £563,270, were exported.

Kauri copal occurs in New Zealand from the thirty-fourth to thirty-eighth degrees of latitude, an area including all that part of the North Island north of Tauranga on the east coast to about Kawhia on the west.

At first large pieces of fossil resin were easily dug up by spades from near the surface of the soil; later, "gum" at considerable depths was located by means of a "gum-spear"—a long, tapered steel rod with a blunt point; with the increase in price of the resin, collection of the smaller pieces became remunerative, and nowadays efforts are made to recover even the small particles of "gum" contained in the soil by the use of various washing and sifting machines.

The simplest form of apparatus consists of a vessel with a perforated bottom; in this the earth is churned up with water by means of a paddle on a central shaft rotated by hand. The residue left on the perforated bottom of the vessel consists of pieces of "gum," wood, and fibrous matter, etc. By drying this residue and winnowing, much of the wood and fibre is removed, though fine, dusty resin is also lost. In large and more efficient plants washing is carried on continuously, and earthy matter is broken up by means of a chain disintegrator. Several sieves of different mesh are used; the material retained by the sieves is winnowed by air current and graded into sizes by screens.

The resin obtained by these washing and sifting processes contains a good deal of foreign material, from which it can be separated conveniently by Maclaurin's process (which has been worked on an industrial scale for some years at the Government's kauri-gum store in Auckland). In this process the crude material is agitated in a conical tank with strong brine (30° Tw., 1·152 sp. gr.),

and air is pumped out. On allowing to stand, the impurities sink and the gum rises to the surface; the "gum" is then washed and dried.

The large pieces are generally washed and scraped by hand, but sand-blasting is said to be cheaper and to clean the resin successfully.

A good deal of resin is also obtained by tapping or bleeding living trees by V-shaped cuts made in the bark, the resin being collected after about six months, and the trees retapped.

After the resin is cleaned it is graded for export, the grading being in the hands of the exporters, who generally sell the resin against samples. In the report of the Commission appointed in 1921 to inquire into and report on the industry, it was considered that the methods of grading seemed somewhat crude, and it was recommended that a standard method should be adopted and a Government grader appointed; so far this scheme does not appear to have been adopted.

The grades of kauri resin vary from "bold," several inches in diameter, down to fine dust, while the colour ranges from very pale amber to black. The finest "rescraped dial" is transparent and very pale in colour; swamp gum is opaque, and the low grades of chips and dust are often contaminated with large amounts of foreign matter. The better qualities are used in the manufacture of varnish, the lower grades chiefly in linoleum manufacture, some 60 per cent. of the resin exported being employed for the latter purpose.

The average value per ton calculated from the export statistics in 1922 is just over £88 per ton. The market prices of kauri resin—in common with other varnish resins—vary very widely according to grade, as the following figures will show:

Grade.	*London.*	*New York, January,* 1924 (*Cents per Lb.*).
Kauri No. 1		63–65
" No. 2		38–40
" No. 3		19–21
Ordinary chips		18–20
Dust, brown		9–10
" white		12–13
X (dark)		75
XX (pale)		75–80
XXX (pale)		92–94
XXXX (pale, extra)		105–110

Dammar.

The term "dammar" is applied to the resins obtained from several different species of trees occurring in Malaya and the Dutch East Indies. It is still stated frequently in textbooks that dammar is the product of *Dammara orientalis;* as a matter of fact, the tree originally bearing the name *Dammara orientalis* was renamed many years ago *Agathis loranthifolia* Salisb. The sources of dammar recognized up to the present appear to be *Agathis loranthifolia*, of the Natural

Order Coniferæ, and several trees belonging to the Natural Order Dipterocarpæ. In the Moluccas the following are the sources of dammar:*

"Damar puteh or poetih" } *Agathis loranthifolia* Salisb.
"Damar radjah" }
"Damar radjak," *Vatica moluccana* Linn. (Natural Order Dipterocarpæ).
"Damar mata-Koetjing" (not determined).

Dammar is exuded naturally from the trees, is obtained from *Agathis* species by tapping, and is also found in the ground around the trees.

Various other trees of the Natural Order Dipterocarpæ, such as species of *Hopea* and *Shorea*, also yield resins of the dammar type. In India "black dammar" is produced by *Canarium strictum*, while *Vateria indica* (the source of Malabar tallow) yields "white dammar," and *Hopea odorata* yields "rock dammar." As far as can be ascertained these are not used as sources of commercial supplies in India, as dammar does not appear in the exports, and considerable quantities are imported to India.

In tapping the trees, cuts are made at intervals over the bark surface; the resin flows slowly, and after some months is collected and the cuts rescraped. In some cases trees are felled, but this practice is naturally undesirable, and steps are taken to prevent felling and to encourage replanting of trees.

In Malaya the following trees are sources of dammar:†

"Dammar mata-kuching" (not determined).
"Damar minjak," *Agathis alba* Foxw.;
"Damar penak" } *Balanocarpus Heimii* and *Balanocarpus Wrayi*;
"Damar chengal" }

while various species of *Hopea* and *Shorea* (Dipterocarpæ) also yield resins of the dammar type.

It appears that there is still some uncertainty as to the exact botanical sources of dammar of some sorts, but the matter is receiving the attention of the authorities in the Federated Malay States, and samples of the various kinds of F.M.S. dammar are being investigated at the Imperial Institute, so that these uncertainties are likely to be cleared up in the immediate future.

In Malaya dammar is chiefly obtained from Negri Sembilan, but also from Selangor and Pahang. Production from year to year is distinctly variable, but appears to be increasing, as there is a good demand even for inferior grades. The following figures show production in the Federated Malay States in recent years:

PRODUCTION OF DAMMAR IN THE F.M.S. (TONS).

1916	212	1920	415
1917	183	1921	532
1918	147	1922	1,396
1919	464		

* *Tydschrift voor het Binnenlandsch Bestuur-Batavia*, 1917, 51, Part 4, 277. See *Int. Rev. Sci. and Pr. Agric.*, 1917, 8, 741.

† *Reports Forest Administration F.M.S.*

The production in Negri Sembilan in 1922 was approximately 1,252 tons out of the above total.

In the Dutch East Indies the production of dammar is very considerable; the trade is largely through Batavia, and exports in recent years and in 1910 and 1913 were as follows:

1910 (metric tons)*	9,808	1919 (metric tons)*	2,765
1913 ,,	9,994	1920 ,,	1,823

The largest export was that of 1917—viz., 10,267 tons.

Dammar is readily soluble in turpentine, and is distinctly softer than most copal resins, but harder than, and much superior to, rosin, though inferior as varnish material to the copal resins. Dammar is particularly useful in cases where pale colour is of importance; it is chiefly used for varnishes for indoor work, owing to the fact that it is not very durable and inclined to have a slightly sticky surface.

A considerable range of varieties appears in trade, named according to the source from which they are derived, such as Batavia, Singapore, Pontianac, Padang, and also graded according to colour.

The prices of dammar vary very widely according to grade. The following prices were quoted on the London market in February, 1924:

	Shillings per Cwt.
Dammar, Batavia (fair to fine)	125 to 160
,, Singapore (specky to fine clear)	30 ,, 150

MINOR RESINS

Acaroid Resin.

The red and yellow resins obtained from various species of *Xanthorrhœa*—tree-like plants of the Natural Order Liliaceæ—which occur only in Australia, mainly in the southern and eastern parts, Kangaroo Island, and in Tasmania, are known by various names such as grass tree, black-boy, yacca.

Red "acaroid," "accroides," or "yacca" resin is yielded by the following species:†

X. arborea R. Br. of Queensland and New South Wales;
X. australis R. Br. of New South Wales, Victoria, and Tasmania;
X. Tateana F. Muell of South Australia;
X. Preissii Endl. of South-West Australia;

while yellow "acaroid" or "yacca" resin is yielded by *X. hastilis* R. Br. of East and South-East Australia. *X. Tateana* is the chief commercial source, and has been worked for over forty years in Kangaroo Island, and more recently in the Second Valley.

* 1 metric ton=1,000 kilos=2,205 lbs.
† *Bulletin No. 6, Dept. of Chemistry, South Australia.*

The tree is a very slow-growing one, and its introduction into other countries is obviously impracticable on this account, and unlikely owing to the low price and limited demand for the resin. In the past the resin has been collected in Australia by very wasteful methods which have led to the destruction of the trees to a considerable extent in some areas. The desirability of employing methods which do not destroy the trees has now been emphasized.

The trunks of the trees are composed of a fibrous core surrounded by dead leaf bases tightly compacted together; the resin occurs between and under the dead leaf bases. The resin is collected by cutting off the leaf bases (leaving a layer of hard resin to protect the core), which are then subjected to a sieving process which separates the resin from the leaf bases, fibre, etc. The resin obtained in this way naturally contains a good deal of foreign matter. Cleaner resin is obtained by steaming the leaf bases on a sieve through which the melted resin drains off.

The red resin is of a very deep brownish-red colour, the yellow resin of a brownish-yellow colour, and it does not appear that any method of decolorizing or appreciably reducing the colour has yet been discovered.

These resins have been known for many years, and a small export trade existed before the War, chiefly to Germany, though comparatively little was known as to their composition, behaviour, or uses, and little or no demand existed for the resins in the United Kingdom.

A good deal of attention was drawn to these resins early in the War, owing to the fact that Germany was the largest buyer and to a rumour that the resin was used for the manufacture of picric acid (for explosives) in Germany.

The resin had long been known to yield picric acid when treated with nitric acid, but numerous investigations have shown that the yields of picric acid are too small, and the consumption of nitric acid far too high to allow of the use of *Xanthorrhœa* resins as a source of picric acid, where phenol (the usual raw material) is obtainable at reasonable prices.

Various other uses for the resin have been suggested and investigated, while in recent years further work has also been done on the composition of the resin.*

Among the suggested uses are the following: varnishes and lacquers, sealing-wax, dyes.

Acaroid resins resemble shellac in being readily soluble in alcohol, but not soluble (or only partly soluble) in most other solvents. Acaroid resins dissolved in spirit give fairly satisfactory results when used as varnishes for wood or lacquers for metal, but the coatings are dark coloured and inferior to those given by shellac, while the fact that the red resin darkens rather rapidly on heating would prevent its use in pale lacquers for "stoving."

The resins can be used in sealing-wax manufacture, but the red resin is only suitable for inferior grades.

The resins themselves are highly coloured and can certainly be made to produce colours on wool and silk, but there seems no hope that they can compete with known natural or artificial dyes. Acaroid resin is not shown separately

* See *Bulletin* 6, *Dept. Chem., South Australia; Bull. Impl. Inst.*, 1920, **18**, 155.

from other resins in the statistics of exports from Australia for 1913, but the total export of Australian-produced resins in that year must represent acaroid resin almost entirely. The following table compares the 1913 export with total exports of acaroid resin in 1920-21 and 1921-22.

EXPORTS FROM AUSTRALIA.

	Total Export of all Australian-Produced Resin.	*Total Exports of Acaroid Resin.*	
	1913.	1920-21.	1921-22.
To United Kingdom	262	695	175
„ New Zealand	½	68	14
„ Fiji	—	3	24
„ France	60½	45	37
„ Belgium	—	145	—
„ Netherlands	—	—	23
„ Germany	902	—	537
„ United States of America	30	181	—
„ other countries	25	-	3
Total .. { Tons ..	1,280	1,137	813
Total .. { Value (£) ..	8,326	14,333	7,826
From New South Wales	198	90	49
„ Victoria	½	12	—
„ South Australia	1,082	1,035	764

The exports to the United Kingdom in 1921-22 are therefore only about a quarter of those in 1920-21, and even less than in 1913, while exports to the United States of America have disappeared; Germany is again taking considerable quantities—though less than in 1913.

Although a fair amount of the resin is being used in the United Kingdom and elsewhere, sellers and users of such materials are somewhat reticent, and it is by no means easy to ascertain exactly the purposes for which it is used; in all probability the great majority is employed in the manufacture of varnishes and stains for wood, as a substitute for shellac in lacquers for metal, and possibly also in linoleum manufacture.

It seems that more might be done to encourage the use of acaroid resin in the United Kingdom.

Acaroid resin sold in February, 1924, in London at about £2 10s. per hundredweight.

SANDARAC.

This is a hard resin, although it is soluble in spirit. It is obtained from a North African tree, *Callitris quadrivalvis* (said to occur also in North America); other species, *Callitris calcarata*, *Callitris glauca*, and *Callitris verrucosa*, growing in Australia, also yield sandarac. Australian sandarac* differs somewhat in appearance and solubility from sandarac from other sources.

* No information as to production of Australian sandarac has been met with.

Sandarac is used on account of its hardness in admixture with softer resins, and for making hard spirit varnishes for photographic negatives, labels, bookbinding, and for wood—*e.g.*, violins.

Sandarac has sold recently in London at 75s. to 100s. per hundredweight (February, 1924).

Mastic.

This resin is obtained from the "lentisc" tree, *Pistachia lentiscus*, growing on the shores and islands of the Mediterranean Sea; much of it is obtained from Greece and the Grecian Islands, particularly Chios from which the best and palest mastic is obtained. It is also obtained in North Africa—*e.g.*, Morocco. The resin is obtained by wounding the tree, which, unlike many resin-bearing trees, such as those yielding copal, has a marked wound-response and may yield up to 10 to 18 pounds a year.

It is readily soluble in turpentine and yields a pale elastic varnish which is useful for varnishing pictures; with boiled linseed oil it forms the artists' medium "megilp," and is often blended with other resins, such as dammar, sandarac, and rosin, for making various kinds of varnish.

In February, 1924, mastic was quoted at 2s. 7d. per pound in London.

Elemi, Canada Balsam, Venice Turpentine.

These are oleo-resins; elemi is derived from trees of the Natural Order Burseraceæ—*e.g.*, Manila elemi from *Canarium luzonicum*—Canada balsam from *Abies canadensis*, and Venice turpentine from *Pinus larix*. Elemi varies considerably in consistence—according to origin and probably also with age—and may be soft and balsam-like or a solid resin. It is obtained from various tropical countries; probably the best-known kind is Manila elemi. Elemi was quoted at 150s. to 180s. per hundredweight in London in February, 1924. Venice turpentine is a soft oleo-resin, while Canada balsam is well known to all who have used the microscope as a clear, very syrupy liquid.

These materials are of little or no importance as varnish materials by themselves, but are used to aid solution of harder resins and to impart flexibility and elasticity to varnishes. They cannot be regarded as of any great technical importance; in fact, one might say that their importance is almost certain to decrease steadily as more scientific methods (and less rule-of-thumb) are applied in varnish-making.

No statistics of production are available, though it is said that 20,000 kilos (nearly 20 tons) of Canada balsam is exported annually from Montreal and Quebec.*

Amber.

This resin is a fossil resin from *Pinus succinifer*, found chiefly on the Baltic shores of East Prussia. It is now but little used for varnish-making as, owing to

* Morrell, *Varnishes and their Components*, p. 106.

its hardness and high melting-point, it yields brittle and dark varnishes. It is of interest to note that a kind of amber has been found in Canada, but seems unlikely to be of any commercial value.

Lacquer.

Although it seems unlikely ever to become an article of much technical importance in modern manufacture, brief mention must be made of this interesting material. In Japan and China the exudation obtained by cutting the bark of the lacquer tree, *Rhus vernicifera*, has been used for many centuries, and all kinds of objects lacquered with this material have long been prized in other countries for their artistic beauty and technical excellence. Lacquer must not be confused with lac-resin (see p. 120).

It is impossible to give here any details of the method of using the sap for the production of a protective coating* for various materials; it will be sufficient to say that the process consists essentially in applying by hand numerous coats of the sap (alone or admixed with other ingredients), each coat being allowed to dry before the next is applied, and that *drying* must be carried out in a very *damp* atmosphere.

The process is tedious and necessitates considerable technical knowledge and manual skill, so that, although lacquered surfaces are very brilliant and durable, and are also resistant to water and many chemicals to a degree not equalled by any other varnish, it is unlikely that the material will be much used outside Japan or China.

A very similar material derived from another tree, *Melanorrhœa usitata*, is known as "Thitsi" in Burma, and used there as in Japan. This material has been submitted to technical examination in England† and shown to behave very similarly to Japanese lacquer, but in spite of its excellence attempts to induce English users of varnishes to employ it were fruitless.

Japanese lacquer also has another drawback—that of irritating or even vesicating the skin—though Burmese lacquer is reputed to do so also; one of the authors experienced no effects when working with it for some time.

* See J. J. Quinn, *Trans. Asiatic Soc. Japan*, 1880; *Bull. Impl. Inst.*, 1910, **8**, 32.
† *Bull. Impl. Inst.*, 1910, **8**, 273; 1917, **15**, 42.

PART II

PRODUCTION AND TRADE OF THE BRITISH EMPIRE

EUROPE

UNITED KINGDOM

Trade in Oilseeds, Oils, and Oilcakes.

Although the United Kingdom had held for many years before the War a very important place among the principal countries engaged in the production and use of oils and oilcakes, Germany was a very serious competitor. A very striking example of Germany's competition with the United Kingdom is afforded by the case of Egyptian cotton seed. In 1905 the United Kingdom imported 94·4 per cent. of the exports of Egyptian cotton seed and Germany less than $\frac{1}{10}$ per cent.; in 1913 imports from Egypt to the United Kingdom were only 51·6 per cent., whilst Germany's import had risen to 45 per cent. Further, the cake produced in Germany from this Egyptian cotton seed was imported in ever-increasing quantities to the United Kingdom—there being little demand for cotton-seed cake in Germany—thus in 1900 the United Kingdom only imported 3 tons of this cake from Germany, but in 1913 the import rose to over 71,000 tons. At the same time strong efforts were being made in Germany to supply the demand there for oilcakes by home production, and to avoid importation of oilcakes from the United Kingdom and elsewhere.

The various aspects of the industry before and during the War were discussed in detail—more particularly with reference to the Indian oilseed trade—in the *Reports on Oilseeds* (*Indian Trade Enquiry, Imperial Institute*), which gave an excellent summary of the whole subject; and it is not proposed to discuss here in detail the relative positions of the United Kingdom and other countries before and after the War, though references to the salient features of the present position compared with pre-war times will be made in the following pages.

Owing to the magnitude of the trade of the United Kingdom in the products under discussion it has been considered advisable to discuss separately the trade in oilseeds, oilcakes, and oils (the latter being divided into three groups—vegetable oils, animal oils, and fish and marine animal oils.

Oilseeds.

No crops of oil seeds of any appreciable importance are produced in the United Kingdom.

Linseed is grown chiefly or wholly for the sake of the fibre, and only an insignificant amount of seed is now produced. During the recent years the largest areas under flax were 143,355 acres in 1918 in Ireland and 23,938 acres in Great Britain, but in 1922 only 34,082 acres and 9,690 acres respectively were grown.

Rape is grown entirely as a fodder crop and no seed is produced for oil, while the growing of hemp for many years has been obsolete. Experiments were made with soya beans during the War, but apparently with no success.

Although linseed, rape, and sunflower seed can be produced in the United Kingdom, it is quite obvious that oilseed crops can be more cheaply grown elsewhere, and the whole of the enormous demand for oilseeds required for the manufacture of oil and feeding cake is met by importation.

IMPORTS OF OILSEEDS TO UNITED KINGDOM (TONS).

	1913.			1922.		
	Empire Sources.	*Foreign Sources.*	*Total (Tons and £).*	*Empire Sources.*	*Foreign Sources.*	*Total (Tons and £).*
Linseed	392,207	262,605	654,812 £7,195,399	159,119	199,730	358,849 £7,011,597
Rape seed	19,299	33,813	53,112 £531,725	32,630	780	33,410 £578,012
Cotton seed ..	231,115	384,217*	615,332 £4,648,617	432,855	51,068	483,923 £4,987,986
Soya beans	5	76,447	76,452 £635,747	—	59,357	59,357 £753,934
Sesame seed ..	—	—	—	14	60	74 £1,402
Castor seed ..	60,198	79	60,277 £710,587	17,743	695	18,438 £305,437
Sunflower	—	—	—	1,694	493	2,187 £28,117
Ground nut: in shell	Included in nuts and kernels		—	31,491	32,044	53,535 £911,776
Decorticated ..			—	9,627	2,594	12,221 £255,970
Copra	24,714	6,154	30,868 £896,707	73,400	12,684	86,084 £2,150,620
Palm kernels ..	Included in other nuts and kernels		36,012†	196,038	16,100	212,138 £3,699,383
Other sorts: Seeds..	2,241	23,049	25,290 £233,240	23,391	22,950	46,341 £587,022
Nuts and kernels, including palm kernels	41,165	9,087	50,252 £1,036,345	—	—	—
Nuts and kernels, excluding palm kernels	—	—	14,240	480	627	1,107 £27,028
Total ..	770,944	795,451	1,566,395 £15,888,367	978,482	389,182	1,367,664 £21,298,284
Approximate percentage of total ..	49	51*	—	71	29	—

* Including Egypt, 238,788 tons.

† *Review Oil and Fat Markets*, 1922, Thornett and Fehr.

The re-exports of oilseeds are in most cases of comparatively little importance in relation to the total imports, as is evident from the following figures: the only oilseeds re-exported in any quantity in 1922 being linseed, copra, and palm kernels, practically all of these re-exports going to the Continent, chiefly to Germany and the Netherlands.

	1913 (*Tons*).	1922 (*Tons*).
Linseed..	5,781	6,547
Rape	325	44
Cotton	128	17
Soya	803	801
Sesame	—	207
Castor	12,827	122
Sunflower	—	213
Ground nut	—	866* 2,778†
Copra	16,664	22,252
Palm kernels	Included with B	5,644
A. Other seeds	3,143	1,422
B. Other nuts and kernels	8,222	328
Total	47,893	41,241
Total imports less re-exports	1,518,502	1,326,423

The influence of re-exports may be practically ignored in a general consideration of the oilseed trade of the United Kingdom, except in the cases mentioned above, to which special reference will be made later.

From a casual review of the above statistics several points are at once evident; thus, there is an increase in 1922, compared with 1913, in the relative proportion of oilseeds imported from Empire sources compared with foreign sources. In the official statistics for 1913 Egypt is included as a foreign country; in 1922 imports from Egypt are included among those of British Possessions. The only importation recorded from Egypt is that of cotton seed, which in 1913 amounted to 238,788 tons. If this quantity is transferred to the total for imports from Empire sources, the result would be as follows:

PERCENTAGE OF TOTAL OILSEED IMPORTS.

Year.		*Empire Sources.*	*Foreign Countries*
1913	Egypt, included with Empire	64·5	35·5
"	" " foreign countries	49·0	51·0
1922	" " Empire	71·0	29·0

An approximate estimate of the production of oil and oilcake can be arrived at readily by converting into the equivalent of oil and cake the quantities of oilseeds imported after deducting oilseeds exported.

* Undecorticated. † Decorticated

The results for 1922 are as follows:

Oilseed.	Total Import Less Export (Tons).	Approximate Yield. Oil (per Cent.).	Approximate Yield. Cake (per Cent.).	Equivalent to Oil (Tons).	Equivalent to Cake (Tons).
Linseed	352,337	30	70	105,702	246,635
Cotton seed	483,905	18	82*	87,102	396,803
Rape seed	33,366	35	65	11,678	21,688
Soya beans	58,556	12	88	7,026	51,530
Sesame seed	†	35	65	—	—
Castor seed..	18,438	42	58	7,644	10,794
Ground nuts:					
In shell	52,669	28	72	14,745	37,921*
Decorticated	9,443	40	60	3,777	5,666
Copra	63,832	65	35	41,491	22,341
Palm kernels	206,494	45	55	92,924	113,570
Other seeds, including sun-flower	47,106	30	70	14,132	32,974
Other kernels	779	40	60	312	467
Total	1,326,925			386,533	940,389

The total quantity of seeds, etc., imported in 1922 has decreased by over 198,000 tons, while the value of imports has risen by about £5,410,000.

Perhaps the most interesting feature is the enormous increase in the use of palm kernels, copra, and ground nuts. The imports of palm kernels have increased in 1922 to nearly five times the quantity imported in 1913, copra over two and three quarters the quantity in 1913, while imports of ground nuts prior to the War were of very minor importance. The large proportions of these products imported from Empire sources compared with foreign countries are also of interest.

	1922. Ground Nut (per Cent.).	1922. Palm Kernel (per Cent.).	1922. Copra (per Cent.).
Empire sources	59	92·4	85·3
Foreign countries	41	7·6	14·7

Linseed.

The total imports of linseed to the United Kingdom in recent years show very curious variations from year to year in the amounts obtained from the chief sources of supply; these variations are so wide that it is desirable to consider separately the import figures for the last few years, compared with those for 1913. Any attempt to gain an idea of averages from the different sources would be misleading.

* Assuming undecorticated cake only is made.
† Omitted.

LINSEED IMPORTS TO UNITED KINGDOM (TONS).

	1913.	1919.	1920.	1921.	1922.
Foreign countries:					
Argentine Republic ..	225,373	216,205	216,265	401,978	178,995
Other foreign countries ..	37,232*	11,743†	27,015‡	24,828‡	20,735§
Total foreign ..	262,605	227,948	243,280	426,806	199,730
British Empire:					
India	136,589	318,953	143,161	41,941	158,231
Canada	255,535	5,585	2,421	602	327
Other Possessions ..	83	426	505	444	561
Total British Empire	392,207	324,964	146,087	42,987	159,119‖
Total (tons) ..	654,812	552,912	389,367	469,793	358,849
Value (£)	7,195,399	20,662,835	15,688,378	8,592,808	7,011,597

Great Britain, therefore, as a rule, derives about 50 per cent., and sometimes rather more, of her supplies of linseed from Empire sources; in 1921, however, owing to the occurrence of a poor crop in India with a bumper crop in the Argentine Republic, only about 10 per cent. of the imports were derived from the Empire. In 1922 nearly 44 per cent. was from Empire sources.

Supplies from Canada have dropped steadily since the War, and at present the United States of America utilizes almost all the linseed exported from Canada, while imports from the United States of America to Great Britain have entirely disappeared since 1921.

	1913 (*Tons*).	1922 (*Tons*).
Total imports of linseed to the United Kingdom	654,812	358,849
Total imports to U.S.A.	231,163¶	372,829
Production in U.S.A.	446,325	305,950
Import and production	677,488	678,779
Shipments to the Continent from:		
India	221,950	130,125
Argentina	827,100	420,000
North America	113,550	—
Russia	64,200	—
Total	1,226,800	550,125
Shipments of the above to:		
Germany..	560,323**	103,155
France	237,350††	137,984††

* Including Russia, 19,849 tons; U.S.A., 8,587 tons. † Including Japan, 5,856 tons.

‡ Including Uruguay, 1920, 5,744 tons; 1921, 14,596 tons; Chile, 5,264 tons.

§ Including Netherlands, 3,228 tons; China, 6,363 tons.

‖ Exports of linseed, 1922, 6,547 tons.

¶ 1914.

** *Bull. Impl. Inst.*, 1917, **15**, 372..

†† From India: 1913, 89,950 tons; 1922, 47,922 tons. From Argentine: 1913, 113,000 tons; 1922, 70,344 tons.

The importance of the linseed industry in the United Kingdom, compared with other countries, is evident from the above figures,* which also serve to show the importance of the Indian export trade in linseed.

It is obvious that at present the greatest demand for linseed in any one country is that of the United States of America, which in 1922 imported nearly 372,900 tons, and also produced nearly 306,000 tons of seed locally.

Rape Seed.

Practically all the import of rape seed is consumed, the largest re-export of seed from the United Kingdom being that of 1920—3,490 tons. The origin of imports of rape seed has, however, varied a good deal in recent years, with a general tendency towards elimination of foreign sources, as is evident from a comparison of figures since 1919 compared with those for 1913.

IMPORT OF RAPE SEED (TONS).

	1913.	1919.	1920.	1921.	1922.
From foreign countries	33,813	2,217	7,246	9,266	780
„ British Possessions	19,299	77,265	22,714	18,811	32,630

In 1913 supplies from Russia were larger than those from India: 23,288 against 19,299 tons; since 1919 no supplies have come from Russia. In 1913, 6,576 tons came from China; 2,419 from the Argentine Republic.

In 1922 British India has supplied practically the whole of the imports, and there is no reason why the demands for rape seed in Great Britain should not be entirely satisfied by India. The average annual output of seed in India before the War was 1,200,000 tons, of which about 240,000 to 260,000 tons was exportable surplus; in 1910-11 over 329,653 tons were actually exported,† and it does not appear that the area under this crop has diminished.

The question of how far Great Britain might absorb a far larger proportion of India's output is of obvious importance to Empire trade; before the War the quantities of rape seed exported from India to several Continental countries were much larger than to Great Britain, as the following figures show:

	1910-11.
Total exported from India	329,653 tons.
To United Kingdom	40,782 „
„ Belgium‡	92,685 „
„ France	79,471 „
„ Germany	92,993 „

It is obvious that Germany has in the past been the chief user of rape seed, followed by France; much of the Continental demand for rape oil might be met by supplies produced in Great Britain and manufactured from Empire-grown

* Official statistics and *Review Oil and Fat Markets,* 1922.

† *Bull. Impl. Inst.*, 1917, **15**, 383.

‡ Chiefly in transit to Germany.

rape seed, if foreign tariffs and freight charges on oil were not so high. At any rate, it seems that rape seed might well be worked to a larger extent in Great Britain, as fair quantities of cake have been imported in recent years (about 10,000 to 12,000 tons a year between 1920-22), as well as some oil, and though the exports of oil exceed imports, the highest export since 1919 is 14,623 tons, and in 1922 only 4,944 tons.

Cotton Seed.

In reviewing the imports of cotton seed to the United Kingdom it is of interest to consider in some detail the sources of supply in recent years.

	1913.	1919.	1920.	1921.	1922.
From foreign countries:					
Total, excluding Egypt ..	145,429	37,455	46,129	61,840	51,068
Total, including Egypt ..	384,217	—	—	—	—
Principal foreign countries:					
Russia	17,770	—	120	—	—
Portuguese India	30,462	4,408	—	—	200
Egypt	238,788	—	—	—	—
Peru	12,745	8,007	11,469	25,977	14,644
Brazil	47,629	18,288	23,056	22,072	23,303
Principal Empire sources:					
Egypt	238,788	247,342	216,944	244,567	282,818
Nigeria	5,360	9	264	9,301	2,078
Kenya Colony	4,172	636	2,890	2,044	3,392
Uganda Protectorate ..	5,142	—	780	95	251
Anglo-Egyptian Sudan ..	—	4,500	6,889	5,076	5,092
British India	213,931	170,601	168,328	51,936	136,928
Other countries	2,510	1,055	618	1,659	2,296
Total from Empire sources	469,903*	424,143	396,713	314,678	432,855
Total all sources ..	615,332	461,598	442,842	376,518	483,923

Over the period 1910-13 it has been estimated† that the exportable surplus of cotton seed from British producing countries amounted annually to 733,000 tons, and that 633,000 tons were required annually in the United Kingdom.

Annual imports of cotton seed since 1919 have, therefore, been considerably less than in 1913. The total import of cotton seed in 1922 is the largest since 1913—viz., 483,923 tons, of which 432,855 tons were derived from Empire sources (Egypt included). The only large foreign sources in recent years are Peru and Brazil. The principal sources of cotton seed imported to the United Kingdom are Egypt and India.

Since the War imports from Egypt have generally represented over 50 per cent. and those from India 30 to 35 per cent. (omitting 1921) of supplies from British sources, while smaller quantities have been derived from various countries such as Nigeria, Uganda, Kenya Colony, and the Sudan, in which the cultivation of cotton on a commercial scale is comparatively modern.

* From Empire excluding Egypt, 231,115 tons.

† *Impl. Inst. Indian Trade Enquiry Rept. on Oilseeds*, p. 32

It appears that Indian exports have for many years come chiefly to the United Kingdom, only small amounts (the highest since 1909—viz., 7,500 tons in 1910)* going to the Continent, while Egyptian seed was, up to 1913, taken in enormous quantities by Continental nations. During the War practically no cotton seed was shipped from Egypt or India to the Continent, and it is only in 1922 that appreciable imports of cotton seed have again been made: 19,600 tons from Egypt and 3,400 tons from India. In 1912, 260,700 tons of Egyptian seed was shipped to the Continent and 322,150 tons to the United Kingdom. Reference has been made previously to the former large consignments of Egyptian seed to Germany (p. 137).

Continental crushers are, therefore, commencing to work cotton seed from the Empire again, and it is to be hoped that oil and cake manufacturers in the United Kingdom will not neglect the possibilities of utilizing even larger quantities than in pre-war days.

Soya Beans.

Although soya beans can be grown in many of the British Possessions, it is evident that no exportable surplus has been produced in any case. Practically the whole of the imports of the United Kingdom are derived from foreign countries, and in very variable quantities in recent years.

Imports of Soya Beans (Tons).

	1913.	1919.	1920.	1921.	1922.
Russia	38,086	—	—	12,063	27,187
China	36,430	2,065	617	4,461	18,470
Japan (including Formosa leased territories in China)	1,929	59,500	13,535	44,901	13,700
Other countries	2	—	825	—	—
Total	76,447	61,565	14,977	61,425	59,357

It appears that the annual requirements of the United Kingdom now amount to 60,000 tons of soya beans, though it is of interest to note that in 1915 over 175,000 tons were imported, and that an average of over 20,000 tons of soya-bean oil (equivalent to about 170,000 tons of beans)† has also been imported annually from foreign countries during 1919-22, while an average of over 10,000 tons of oil was exported.

Soya-bean oil has been largely used to replace American cotton oil and supply the need for liquid oils in the manufacture of margarine, owing to no surplus of American cotton oil being available in recent years for import to the United Kingdom.

There is, undoubtedly, a large demand for soya-bean oil in the United Kingdom—a demand which might be increased by home consumption or by exportation to the Continent of oil and cake—but the fact remains that cultivation of this

* *Review Oil and Fat Markets*, 1922, p. 92.

† Assuming the yield of oil obtained to be 12 per cent.

crop has not led to the production of exports from Empire sources, and it is possible that the seed cannot be grown sufficiently cheaply in competition with the enormous Chinese and Manchurian supplies.

Sesame Seed.

As mentioned previously, this seed has only been imported to the United Kingdom in any quantity during the War, when supplies were diverted from the Continent. Prior to the War, small quantities were occasionally imported, probably more for use in compound cake than as a source of oil; since the War the largest import of this seed is that of 1920, 5,468 tons, of which only 815 tons came from British Possessions. It is a most regrettable fact that this valuable seed does not seem to meet with favour from English oilseed crushers, as it is grown on a large scale in India and in fair quantities in other British Possessions —*e.g.*, the Sudan, East Africa, etc.—and it seems that its cultivation might well be extended. Possibly the reason for the small importance of this oilseed, and also of the oil in the United Kingdom, is to be traced to the excellent demand on the Continent (see p. 68) already referred to.

Castor Seed.

The imports of castor seed to the United Kingdom do not call for any very special comments beyond the observations that supplies have been drawn practically entirely for many years past from India,* and that the imports from 1919-22 are very much lower (1922 is the highest) than in pre-war times.

During the War the demand for castor seed was very large—oil of any kind was wanted, and castor oil was particularly needed for lubrication of internal combustion engines; this decreased demand for seed is not easy to explain.

Sunflower Seed.

This seed has never assumed any great importance as an oilseed in the United Kingdom, though it has been imported from time to time from South Russia, where it is of considerable importance.

The sunflower has been recommended frequently as an oilseed crop suitable for " cultivation in many British Possessions, and has been grown to some extent in South Africa for some years past, and now appears to be of increasing importance in India. Of the total imports of 1922—amounting to 2,187 tons— 1,569 tons were derived from India and 124 tons from South Africa. It is to be hoped that the production of this seed will increase in these countries and elsewhere, as there seems to be no difficulty in disposing of the seed in the United Kingdom. The price obtainable for the seed is not high, but cultivation is not difficult or costly, and if properly organized, should be profitable.

* During the War supplies were obtained from various other sources.

Ground Nuts.

Prior to the War ground nuts were regarded as of little importance as a source of oil and oilcake in the United Kingdom, and the imports of ground nuts were so insignificant as not to be recorded separately. During the War large supplies of ground nuts formerly worked on the Continent—chiefly in France, followed by Germany, the Netherlands, and Italy—were diverted to the United Kingdom; since the War very considerable quantities of ground nuts have been imported annually, though latterly importation has decreased gradually to the United Kingdom and increased to the Continent.

It is desirable to quote in some detail the recent statistics relating to imports of ground nuts to the United Kingdom, as these show a good deal of variation from year to year, particularly in connection with the sources of supplies.

IMPORTS OF GROUND NUTS TO UNITED KINGDOM (TONS).

	1919.	1920.	1921.	1922.
Undecorticated	Not recorded	81,171	61,998	53,535
Decorticated	separately	43,123	33,405	12,221
Total (tons)	107,108	124,294	95,403	65,756
Value (£)	3,948,900	4,886,092	1,799,059	1,167,746
From British Possessions:				
Undecorticated	—	75,332	45,407	31,491
Decorticated	—	39,277	30,824	9,627
Total	100,977	114,609	76,231	41,118
Total from foreign countries: ..	6,131	9,685	19,172	24,638
For comparison: Exports from United Kingdom	521	1,843	11,070	3,644

It is obvious that the bulk of the imports are derived from sources within the Empire, and it is quite certain that these sources might well supply the whole of the United Kingdom demand for ground nuts. The imports from foreign sources need not be discussed in detail, the chief source being French West Africa, from which 19,307 tons were derived in 1922, while 1,494 tons were obtained from Portuguese West Africa.

With regard to the origin of supplies from British Possessions, the following figures show some rather interesting fluctuations:

IMPORTS (TONS).

From:	1919.	1920.	1921.	1922.
Gambia U.*	57,854	62,591	41,176	29,891
„ D.*	—	2,038	868	174
Nigeria U.	—	9,696	1,711	503
„ D.	34,673	28,449	11,182	865
British U.	—	—	—	—
East Africa D.	—	235	873	2,155
India U.	7,606	2,646	2,345	480
„ D.	—	8,309	17,435†	6,334
Other British Possessions U.	409	399	175	617
„ „ D.	—	246	465	99

U=Undecorticated, D=decorticated. † Including Ceylon in 1921, 3,881 tons.

It will be seen that the largest imports are generally those from Gambia in the form of undecorticated nuts, and from Nigeria as decorticated nuts, whilst a considerable amount of decorticated Indian nuts—17,435 tons, including 3,881 from Ceylon—was imported in 1921.

The great reduction in imports of ground nuts to the United Kingdom in 1922 is not attributable to any deficit in supplies, but is obviously due to enormous demand on the Continent—chiefly by France. Before the War France utilized annually 450,000 to 500,000 tons of ground nuts, and in 1922 imported 238,879 tons of undecorticated and 222,285 tons of decorticated nuts, a total of 461,264 tons.

Ground nuts might well be worked to a greater extent than at present in the United Kingdom, as fairly large amounts of both cake and oil are imported to satisfy the demand. The following figures show distinctly that the United Kingdom demand is not met entirely by the home oil-crushing industry.

	1920 (*Tons*).	1921 (*Tons*).	1922 (*Tons*).
Ground-nut cake:			
Imports	27,564	45,889	59,519
Exports	4,562	1,093	224
Re-exports	7,374	203	1,522
Difference: Imports (less exports + re-exports)	15,628	14,593	44,073
Ground-nut oil:			
Imports	10,250	8,965	7,970
Exports and re-exports	1,395	3,464	3,657
Difference: Imports (less exports + re-exports)	8,855	5,501	4,313

The decrease in working of ground nuts in the United Kingdom since the War is to be attributed largely to the cost of shipment to the United Kingdom compared with France; Marseilles, the centre of the French ground-nut industry, being more favourably situated with relation to India, West Africa, and China, the chief commercial sources of ground nuts.

Copra.

A comparison of the following figures for imports to and exports from the United Kingdom serves to indicate the increasingly important position of copra in the oilseed-crushing industry.

Copra Imports and Exports (Tons).

	1913.	1919.	1920.	1921.	1922.
Imports..	30,868	71,531	57,368	54,685	86,084
Exports..	16,664	3,545	14,937	17,921	22,252
Difference	14,204	67,986	42,431	36,764	63,832

The greatly increased demand for copra—largely for the manufacture of refined oil for margarine—is very evident, an average of over 52,000 tons being retained in the country each year from 1919-22, compared with about 14,000 tons in 1913.*

* Detailed figures prior to 1913 not available.

In considering the increased demand for copra in the United Kingdom it is desirable also to compare the imports to the other important consumers, France, Germany, and the United States, in 1913 and 1922.

IMPORTS (TONS).

	1913.	1922.
To France	123,360	113,294
,, Germany	196,449	282,676
,, Holland	100,635*	168,446
,, United States of America	20,284	112,812

Thus France has nearly regained her pre-war position, Germany's imports have increased considerably, and the import to the United States has increased more than fivefold; it is therefore evident that the present large imports to the United Kingdom are not due to diversion of supplies from other nations.

Although the demands for copra have increased enormously on all sides the supplies have also increased; before the War the world's total exportable surplus was about 540,000 tons a year, and now probably amounts to about 900,000 tons,† due to the great increase in coconut planting in the tropics, and to new plantations coming into bearing. The chief factor which might limit supplies of copra to Europe would be a fall in price below the limit at which collection and preparation of copra would be unremunerative.

The following table indicates the sources of imports of copra to the United Kingdom:

	1913 (Tons).	1922 (Tons).
From foreign countries:		
Dutch East Indies	307	2,281
Portuguese East Africa	623	1,767
Philippine Islands	3,410	7,400
Other countries	1,814	1,236
Total	6,154	12,684
From British Possessions:		
British East Africa	29	1,421
British India	3,185	4,240
Straits Settlements, etc.	6,126	30,438
Federated Malay States	465	474
Ceylon, etc.	172	14,325
Australia‡	7,377	4,690
New Zealand§	5,404	2,817
Fiji Islands	42	6,280
West Indies	404	3,211
Other countries	1,510	5,504
Total British	24,714	73,400
Total all sources	30,868	86,084

* Re-export, 82,356, chiefly to Germany.

† A recent estimate puts the 1923 world's shipment at over 1,000,000 tons (*Review Oil and Fat Markets*, 1923; Faure, Blattman and Co.).

‡ Principally New Guinea, Papua, and South Sea Islands.

§ Principally South Sea Islands.

It is interesting to note that prices of copra in 1922—£23 3s. to £25 8s. per ton—were rather below those ruling just before the War—viz., £26 to £28 per ton.*

In 1922 the United Kingdom demands were largely met by copra from within the Empire, nearly seven-eighths of the total imports being derived from British Possessions, the Straits Settlements, Ceylon, and the Fiji Islands being the chief sources in the order named.

A considerable amount of coconut oil is also imported to the United Kingdom, and of this the majority is consumed, as will be seen from the following figures for imports and exports on page 153.

To summarize briefly the position in the United Kingdom, it is evident that there is a sustained demand for copra, coconut oil, and coconut cake greatly in excess of pre-war requirements, and that the demand is largely met by imports of copra and coconut oil from the Empire. It seems that the working of copra might well be developed further, as home consumption of coconut oil is evidently in excess of production, and the cake is now deservedly popular and largely used for feeding.

Palm Kernels.

The increased importance of palm kernels in the United Kingdom since the outbreak of war is one of the most striking features of the vegetable oil industry.

The following figures show the relatively small importance before the War of the United Kingdom imports compared with those of Germany, and the present state of imports.

IMPORTS.

	1909.	1913.	1922.
To United Kingdom	17,306	36,012	212,138
„ Germany	235,616†	254,454†	126,880†

The largest import of palm kernels to the United Kingdom in any one year is that of 1919, when over 304,000 tons were imported; in the two following years the imports were as follows: 1920, 286,526 tons; 1921, 239,213 tons. Germany has therefore begun to regain, to some extent, the important pre-war position in the palm-kernel trade, particularly since the removal of the £2 per ton export duty on kernels shipped from West Africa to foreign countries.

The demand for palm kernels—largely for oil for margarine manufacture—is therefore well sustained, and so far Germany has not regained her pre-war lead in working palm kernels. The statistics for 1922 serve well to indicate the sources of supply of palm kernels.

Approximately twenty-four twenty-fifths of the total imports are obtained from British sources, and practically the whole of the imports‡ are worked up in the United Kingdom. Further, it is obvious that practically the whole of the

* For recent prices see p. 82.

† *Review Oil and Fat Markets*, 1922, p. 57. Hamburg and Harburg only, 1909-1913; Germany, 1922 (p. 60). *Impl. Inst. Indian Trade Enquiry Rept.* gives 264,361 met. tons=261,500 tons for total German output in 1913.

‡ In 1922, 5,644 tons of kernels were re-exported.

oil produced is consumed in the country, as a comparatively small quantity of palm-kernel oil (8,089 tons) was exported in 1922.*

IMPORTS OF PALM KERNELS TO UNITED KINGDOM, 1922 (TONS).

From British Possessions:	
Gambia	323
Sierra Leone	39,062
Gold Coast (and Togoland)	1,990
Nigeria (and Cameroons)	154,497
Other sources	166
Total British	196,038
From foreign countries:	
French West Africa	13,955
Other countries	2,145
Total foreign	16,100
Total	212,138

Speaking broadly, palm kernels and copra are interchangeable, the oils from both being of enormous importance in the margarine industry. Coconut oil is rather more valuable than palm-kernel oil, and copra is also richer in oil than palm kernels, but the ease of handling kernels and the less storage space occupied per ton are factors of sufficient importance as to render kernels a very serious competitor which may in the future tend to replace copra more or less in the world's markets.

One interesting feature of the trade in palm kernels might be mentioned—*i.e.*, that the present price of kernels is lower than that ruling in 1913, and almost the same as that in 1909, while recent prices of oil are lower than pre-war prices.

LIVERPOOL PRICES.

		1909.		1913.		1922.		1923.	
		£	s.	£	s.	£	s.	£	s.
Kernels:									
Price per ton	From	14	8	21	18	16	10	17	0
	To	17	12	24	10	18	17	21	6
Oil:				*In Barrels.*		*Naked.*			
Price per ton	From	—		40	0	33	15	36	0
	To	—		49	10	39	10	44	5

OIL IMPORTS AND EXPORTS.

Many different kinds of oils are imported and exported, in some cases in relatively small quantities. It is therefore convenient to group these together under the following headings, and to consider each group separately:

Group 1. Vegetable oils, including all oils derived from fruits and seeds.
Group 2. Animal oils, such as tallow and lard.
Group 3. Fish, fish-liver and whale oils.

* Palm-kernel cake is not recorded separately in official statistics, so that it is not possible to estimate home consumption exactly.

Group 1.—Vegetable Oils.

IMPORTS OF VEGETABLE OILS TO UNITED KINGDOM (TONS).

Oil.	1913. Unrefined.	1913. Refined.	1922. Unrefined.	1922. Refined.
Linseed:				
F.*	11,884	—	3,455	471 (refined) 128 (boiled)
B.†	14	—	—	—
Total	11,898‡	—	3,455	599
Value (£)	310,670	—	134,472	19,631
Rape seed:				
F.	7,599	—	1,239	—
B.	—	—	12	—
Total	7,599	—	1,251	—
Value (£)	222,556	—	56,057	—
Cotton seed:				
F.	1,061	16,580	522	817
B.	9	6	1,054	2,405
Total	1,070	16,586	1,576	3,222
Value (£)	31,748	558,277	58,058	139,528
Soya bean:				
F.	Included in		20,357	—
B.	" other oils "		—	—
Total			20,357	—
Value (£)			735,808	—
Sesame:				
F.	Included in " other oils "		35	—
Value (£)			2,178	—
Castor seed:				
F.	1,067	—	1,268	—
B.	332	—	1,247	—
Total	1,399	—	2,515	—
Value (£)	41,875	—	122,243	—
Olive:				
F.	2,882	6,163	2,810§	4,984§
Value (£)	130,191	385,257	174,829	411,298
Ground nut:				
F.	Included in		5,222	2,736
B.	" other oils "		—	12
Total			5,222	2,748
Value (£)			229,913	179,165

* F.=from foreign countries.
‡ Including 32 tons " not pure."
† B.=from British Possessions.
§ 1 ton ex British in each case.

IMPORTS OF VEGETABLE OILS TO UNITED KINGDOM (TONS)—*Continued.*

Oil.	1913.		1922.	
	Unrefined.	*Refined.*	*Unrefined.*	*Refined.*
Coconut:				
F.	21,761	26,897	10,759	9,057
B.	9,379	440	17,790	784
Total	31,140	27,337	28,549	9,841
Value (£)	1,342,469	1,316,246	1,134,982	485,920
Palm kernel:*				
F.	—	2,902	303	123
B.	—	10	139	—
Total	—	2,912	442	123
Value (£)	—	141,967	20,237	8,906
Palm oil:				
F.	6,495	—	11,298	—
B.	71,615		59,968	—
Total	78,110		71,266	—
Value (£)	2,326,842	—	2,321,492	—
Other vegetable and seed oils:				
F. (not enumerated)	20,274		2,546	1,809
B.	106		133	2
Total	20,380		2,679	1,811
Value (£)	767,810		141,930	135,294
"Oil unenumerated":				
Estimated tons†	37,000		—	—
Value (£)	129,407		—	—

In comparing the total crude or unrefined oil imports of 1913 with those of 1922, allowance must be made for a quantity of "oil unenumerated," value £129,407 in the official returns. At an average price of £35 per ton this will represent about 37,000 tons of oil, bringing the total unrefined oil imports to 154,478+37,000=191,478 tons in 1913, compared with 140,157 in 1922, indicating a decided decrease in imports of unrefined oils.

Imports of refined oils have decreased in 1922 to nearly one-half of the quantity in 1913, no doubt due to the greatly increased capacity of oil-manufacturing and refining plant in the United Kingdom.

Taking the different oils separately, it is seen that imports of *linseed oil* have decreased from over 11,800 tons in 1913 to a little over 4,000 tons in 1922. Imports of *rape-seed oil* in 1922 are less than one-sixth of those in 1913. The figures for *cotton-seed oil* are distinctly interesting. The quantities of unrefined oil imported are in both years comparatively small, but two-thirds of the 1922

* Including refined palm oil in 1913.

† Assuming £35 per ton.

import is from Egypt, while practically the whole of the 1913 import was from China and the United States. The import of *refined cotton-seed oil* in 1922—about three-fourths of which was derived from Egypt—is less than one-fifth of the import of 1913, which was principally from the United States. No comparison between 1913 and recent years can be made for *soya-bean oil*, but it might be noted that considerable quantities of crude soya-bean oil enter the port of London —generally in bulk tanks in Japanese vessels—and, after sampling, are reshipped to the Continent, principally to Belgium and Holland.

Although soya beans have been experimentally grown in many British Possessions, they do not yet appear to have attained any importance as an oilseed; whether they will do so only time can show. At present soya beans are so cheaply produced in Manchuria and China that their profitable cultivation as an oilseed elsewhere seems doubtful. It must be remembered that the plant is resistant to distinctly adverse climatic conditions, and valuable as fodder and as a green manure, and that its cultivation, both as an oilseed crop and for fodder, has grown rapidly in recent years in the United States of America.

Imports of *sesame oil* are too insignificant to mention; apparently oil refiners and users in this country are content to allow this oil to be absorbed on the Continent (see p. 67). Imports of *castor oil* in both years are small, but in 1922 practically half the total import was from India. Imports of *olive oil* are in all cases from foreign countries, this oil not being produced in any quantity in British Possessions (see p. 64).

The *ground-nut oil* imports are derived from foreign countries—crude oil chiefly from Japan and China, refined oil chiefly from the Netherlands. Most of the home demand for this oil is met by imports of seed, and it certainly seems that efforts might be made in India and Burma to compete with Chinese and Japanese exports of the oil. Up to the present practically all of the ground-nut oil produced in Burma has been absorbed locally.

The imports of *crude coconut oil* are practically the same in 1922 as in 1913, but imports of refined oil have decreased to a little over one-third. This decrease is no doubt due to increased facilities for manufacturing and refining such oils in the United Kingdom.

The total imports of coconut oil in 1922 show a considerable decrease compared with those of 1913, but the average total import for the years 1919-22 amounts to 58,490 tons.

The following table shows the proportions of imports from foreign and British sources in 1913 and 1922, and also the amounts of oil exported.

Coconut Oil (Tons).

Imports from:	1913.	1922.
British Possessions	9,819	18,574
„ foreign countries	48,658	19,816
Total imports	58,477	38,390
Exports (total export and re-export)	9,773	3,775
Difference (import less export)	48,704	34,615

It is evident that supplies are now drawn to a much larger extent from British Possessions than before the War, chiefly from Ceylon, which supplied 14,867 tons in 1922; the chief source among foreign countries in that year being the Netherlands, with 17,449 tons. In 1913, 30,381 tons out of a total import of 58,477 tons was derived from Germany.

The imports of *palm-kernel oil* are too small to merit much attention, though it is of interest to note that 139 tons of this oil came from Nigeria in 1922; and in 1920, 3,342 tons were imported from Nigeria.

Palm oil has for many years been imported to the United Kingdom in large quantities, principally from the southern part of Nigeria, from which over 57,500 tons of the total from all sources—73,077 tons—was derived in 1922. The quantities from Sierra Leone and the Gold Coast are small, 1,448 tons and 395 tons respectively. The principal foreign sources of palm oil in 1922 are French West Africa, 4,343 tons; the Belgian Congo, 2,169 tons; the Netherlands, 1,613 tons (no doubt re-export); and—most interesting of all sources—Dutch possessions in the Indian Seas, 1,199 tons, presumably derived from the recent Dutch oil-palm plantations in the east of Sumatra (see p. 85).

Vegetable Oil Exports.

In the following table are given the exports and re-exports of the various vegetable oils, to which are added, for convenient reference, the totals for imports of these oils:

VEGETABLE OILS: EXPORTS AND RE-EXPORTS

			Linseed.	*Rape.*	*Cotton.*	*Soya.*	*Olive.*
1913	Exports	Tons	29,911	5,839	25,535	9,390	324
		£	880,833	175,846	770,536	294,238	46,670
	Re-exports	Tons	881	3	947	—	1,126
		£	21,819	161	30,640	—	84,239
1922	Exports	Tons	59,388	4,944	10,576	8,097	85
		£	2,352,101	217,123	497,481	374,428	24,238
	Re-exports	Tons	13	2	189	183	144
		£	558	142	4,969	6,839	17,769

IMPORTS (FOR

1913 (tons)	11,898	7,599	17,656	—	9,045
1922 (tons)	4,054	1,251	4,798	20,357	7,794

Taking a broad survey of the export figures, and omitting the re-export figures, which, with the exception of coconut and palm oils, are not of any great moment, the following are the chief points of note:

Linseed Oil.—The exports in 1922 are more than double those in 1913; i 1922, however, only 9,671 tons went to British Possessions out of a total expo of 59,388 tons; in 1913, 95,361 tons,* or over half the total export, went to Britis Possessions.

The exports to British Possessions are mostly divided in small quantitie between practically all parts of the Empire, the largest export in 1922 being tha to Australia—viz., 2,876 tons (raw oil, 1,855 tons; boiled oil, 782 tons; refine oil, 239 tons). It is curious that Australia should import linseed oil from th United Kingdom; linseed can be grown in Australia, and is grown there t some extent (see p. 231), and is also imported to Australia from New Zealan and elsewhere; further, linseed oil is manufactured in Australia, in evidence o which may be quoted the fact that imports of linseed cake to the United Kingdon from Australia amounted to 7,820 tons and 4,462 tons in 1921 and 1922 respec tively. The exports of oil from the United Kingdom to India amounted in 1922 to 1,112 tons, including 995 tons boiled oil. There is no reason wh Indian oil factories should not be able—with proper plant and skilled super vision—to produce linseed oil and boiled oil of good quality from home-grow seed, as their manufacture does not entail any great difficulties.

Rape Oil.—Exports of rape-seed oil in both 1913 and 1922 are comparativel small; the exports have varied widely since 1920, when 14,623 tons were exporte (6,596 tons to the Netherlands, 2,734 to Germany, 3,034 to Belgium, and 1,073 to France); in 1921 only 2,692 tons were exported. In 1913 and in 1922 the United States was the largest buyer, taking about 3,800 tons in each year. The quantities exported to British Possessions are in all cases small (542 tons in 1913, 89 tons in 1922), and no details are available as to the countries to which these were sent.

M THE UNITED KINGDOM, 1913–1922.

stor.	*Ground Nut.*	*Coconut.*	*Palm Kernel.*	*Palm.*	*Other Sorts.*
,818	—	6,049	1,808†	46,244	2,287
,839	—	269,242	67,265	1,308,050	61,240
31	—	3,624	—	—	1,237
,674	—	157,763	—	—	45,006
,136	3,544	1,669	8,089	951	5,623
,781	162,264	79,097	296,469	37,124	235,647
59	113	2,106	—	19,839	865
,192	5,631	92,257	—	638,666	51,248
MPARISON).					
,399	—	58,477	2,912	78,110	20,380
,515	7,970	38,390	565	73,077	4,490

* Including 1,400 tons to Egypt. † Including, in 1913, refined palm oil.

Cotton-Seed Oil.—The following figures indicate the amounts of unrefined and refined oil exported in 1913 and 1922, and the proportions of these sent to British Possessions and foreign countries:

	1913 (*Tons*).	1922 (*Tons*).
Refined oil to:		
British Possessions	1,491	859
Foreign countries	23,522	8,326
Total	25,013	9,185
Unrefined oil to:		
British Possessions	319	38
Foreign countries	203	1,353
Total	522	1,391

The exports of unrefined oil are principally to the Continent, chiefly the Netherlands, which country took 860 tons in 1922; no details are available as to countries in connection with the small exports to British Possessions. The exports of refined oil to foreign countries were almost entirely to the Continent in 1922, the principal buyers being Denmark, 1,123 tons; Germany, 1,281 tons; and the Netherlands, 3,798 tons. The largest exports to British Possessions in 1922 were those to British West Africa, 204 tons, and British Guiana, 421 tons.

Soya-Bean Oil.—The exports of soya-bean oil have varied during 1919-22 from 1,039 tons in 1919 to 10,435 tons in 1920. The largest importer among foreign countries is Italy, which took 4,850 tons in 1922, the remaining exports going to various Continental countries. Out of 715 tons exported to British Possessions in 1922, 645 tons were exported to Malta and Gozo.

Olive Oil.—Exports of olive oil consist almost entirely of refined oil; only 20 and 19 tons of unrefined oil were exported, and 313 and 68 tons re-exported, in 1913 and 1922 respectively. The small exports (56 tons) of refined oil in 1922 were distributed as follows: India 21 tons, Australia 7 tons, New Zealand 10 tons, Canada 1 ton, other British Possessions 17 tons, foreign countries 10 tons. Re-exports of refined olive oil to British Possessions amounted to 42 tons in 1922 (South Africa 6, Australia 11, Canada 17, New Zealand 7 tons).

Castor Oil.—The great bulk of the exports of this oil go to foreign countries, which in 1922 took 3,321 tons, compared with 815 tons to British Possessions. The largest exports to foreign countries in 1922 were those to Germany, 1,819 tons (in 1913 Germany took 6,686 tons), and the United States, 512 tons. Among British Possessions Canada is the largest buyer, with 447 tons in 1913 and 395 tons in 1922; in the latter year 152 tons went to Australia.

Ground-Nut Oil.—Exports of this oil are comparatively small, and it is obvious that the bulk of the oil produced from imported ground nuts is consumed in home manufacture. No details of exports of ground-nut oil are available before 1920. In 1922, 1,345 tons of unrefined oil went to foreign countries (Netherlands 723 tons, Belgium 435 tons), and 9 tons to British Possessions; 2,163 tons of refined oil went to foreign countries (1,247 tons to the Netherlands), and 27 tons to British Possessions.

Coconut Oil.—The exports and re-exports of coconut oil in 1913 and 1922 were as follows:

	1913.		1922.	
Exports to:	*Unrefined* (*Tons*).	*Refined* (*Tons*).	*Unrefined* (*Tons*).	*Refined* (*Tons*).
Foreign countries..	3,096	2,069	254	1,278
British Possessions	7	877	5	132
Total	3,103	2,946	259	1,410
Re-exports to:				
Foreign countries..	2,928	518	1,218	844
British Possessions	117	61	41	3
Total	3,045	579	1,259	847
Total export + re-export..	6,148	3,525	1,518	2,257

The exports and re-exports of coconut oil are, therefore, small in relation to imports of oil and copra, and have decreased from 9,763 tons in 1913 to 3,775 tons in 1922. Considered in conjunction with the greatly increased imports of copra in recent years, the above facts afford further evidence of the largely increased demand for coconut oil in the United Kingdom. In all cases the bulk of the exports and re-exports of both refined and unrefined oils are shipped to foreign countries—chiefly to Continental countries such as Russia, Denmark, Netherlands, and Germany. In 1922 only a small proportion of the total exports and re-exports was shipped to British Possessions, principally in the form of refined oil.

Palm-Kernel Oil.—It will be seen that exports of palm-kernel oil in 1922 are much larger than in 1913, the 1913 export including also refined palm oil, quantity not recorded.

The following figures show the relative amounts of refined and unrefined oils and destinations in 1913 and 1922:

	1913.		1922.	
Exports to:	*Unrefined* (*Tons*).	*Refined* (*Tons*).	*Unrefined* (*Tons*).	*Refined* (*Tons*).
British Possessions	246	33	179	31
Foreign countries..	804	725	6,099	1,780
Total	1,050	758	6,278	1,811

In all cases the bulk of the export is to foreign countries, chiefly to Continental countries; in 1922 Belgium was the largest buyer of refined oil, with 1,181 tons, followed by the Netherlands, 414 tons, and the United States, 138 tons. The Netherlands was also the largest buyer of unrefined oil, 3,449 tons, while 1,309 tons were shipped to the United States, and 690 tons to Germany.

Reference has been made previously (p. 149) to the increased importance of palm-kernel oil in the United Kingdom, and it is obvious that the large demand

for palm-kernel oil is now met by home manufacture from imported kernels, as only an insignificant amount of oil was imported in 1922—viz., 565 tons —while 8,089 tons of oil were exported.

The working of palm kernels in the United Kingdom might be increased with benefit to British West African Colonies which produce kernels and to manufacturers in the United Kingdom, as there is ample plant for expressing or extracting the kernels, but a market would have to be found for oil produced in excess of home requirements. The principal buyers are the various Continental countries, which in most cases impose tariffs on imported oils. The demand for palm-kernel oil in the United States might be increased, as coconut oil has increased enormously in importance in recent years in this country; and according to the present tariff rates (since September 21, 1922) import of palm-kernel oil is free, while coconut oil is rated at 2 cents per pound.

Palm Oil.—Exports of palm oil must really be regarded in the light of re-exports, as these refer almost entirely to unrefined oil imported (chiefly to Liverpool) from West Africa and reshipped. In 1922, 394 tons of unrefined oil was recorded under "exports of produce and manufacture of the United Kingdom," though there seems no valid reason for this classification; in addition, 557 tons of refined palm oil is also recorded (242 tons to United States of America, 103 tons to Italy); the total quantity classifiable under "exports" is, therefore, only 951 tons.

The following table shows the "exports" to foreign countries and to British Possessions in 1913 and 1922 (including 951 tons referred to above as exported in 1922):

Exports to:	1913 (*Tons*).	1922 (*Tons*).
British Possessions	294	749
Foreign countries..	45,950	20,041
Total	46,244	20,790

The exports of palm oil to British Possessions are, therefore, inconsiderable in 1922. Four hundred and sixty tons were shipped to Egypt and 125 tons to Canada. The total export for 1922 is less than one-half that of 1913, partly accounted for by reduction in shipments to the largest buyer, the United States of America. In 1913, 18,490 tons were shipped to the United States, and only 11,360 tons in 1922. This reduction in exports from the United Kingdom to the States is due to the increased tendency to ship direct from West Africa to America,* where the demand for palm oil is increasing rapidly. The above conclusion is evident from the following figures:

	1920 (*Tons*).	1921 (*Tons*).	1922 (*Tons*).
United Kingdom exports	35,756	25,261	20,790
U.S.A. imports	18,727	10,337	25,677

* Recent U.S.A. tariff admits palm oil free.

Exports and re-exports of seed and vegetable oils of "other kinds"* in 1922 were made up as follows:

	Exports.			*Re-Exports.*		
	Crude Seed.	*Crude Vegetable.*	*Refined.*	*Crude Seed.*	*Crude Vegetable.*	*Refined.*
To foreign countries ..	877	1,927	2,218	5	652	207
,, British Possessions	14	308	279	—	1	—
Total (tons) ..	891	2,235	2,497	5	653	207
Value (£)	36,045	77,804	121,798	366	38,375	12,507

The proportions of such oils as are recorded above shipped to British Possessions are small, and generally no details are available to indicate the nature of these exports or the destinations.

Group 2.—Animal Oils.

In the following table are given import, export, and re-export statistics for 1913 and 1922 relating to lard; imitation lard, oleo-margarine, oleo-oil (the liquid oil separated from the stearine of animal oil), and refined tallow; grease of animal origin and unrefined tallow, together with unclassified animal oils and fats and stearine.

	Lard.†		*Imitation Lard.*		*Oleo-Margarine, Oleo-Oil, and Refined Tallow.*	
	1913.	1922.	1913.	1922.	1913.	1922.
Imports from:						
Foreign countries	96,041	110,881	11,202	4,597	14,317	24,451
British Possessions ..	4,227	4,086	24	33	4,561	5,479
Total (tons)	100,268	114,967	11,226	4,630	18,878	29,930
Value (£)	5,552,462	7,653,753	465,503	296,473	858,130	1,480,698
Exports to:						
Foreign countries	112	78	11	150	12,213	3,238
British Possessions ..	197	201	87	128	712	251
Total (tons)	309	279	98	278	12,925	3,489
Value (£)	21,902	21,740	4,605	16,053	526,446	139,783
Re-exports to:						
Foreign countries	14,902	189	226	3	8,623	8,980
British Possessions ..	339	239	33	2	65	442
Total (tons)	15,241	428	259	5	8,688	9,422
Value (£)	865,450	30,096	11,237	480	783,312	410,782
Total export and re-export (tons)	15,550	707	357	283	21,613	12,911

* Quoted in *United Kingdom Trade Returns* as "other seed oils not elsewhere specified," "other vegetable oils not elsewhere specified," and (refined edible) oils "other sorts: refined not elsewhere specified."

† Refined lard.

	Tallow (Unrefined), Grease, and Animal Fats.		Other Animal Oils and Fats.		Stearine.	
	1913.	1922.	1913.	1922.	1913.	1922.
Imports from:						
Foreign countries	27,291*	15,666	10,793	2,991	4,033	2,734
British Possessions	67,813	43,045	423	788†	96	442
Total (tons) ..	95,104	58,711	11,216	3,779‡	4,129	3,176
Value (£) ..	3,207,628	2,169,483	298,026	179,056	167,444	164,972
Exports to:						
Foreign countries	31,686	15,182	Included with tallow, etc.	856	Included with tallow	1,382
British Possessions	3,260	782		55		798
Total (tons) ..	34,946	15,964	—	911§	—	2,180
Value (£) ..	848,100	470,506	—	38,276	—	93,469
Re-exports to:						
Foreign countries	45,848	20,833	261	782‖	425	48
British Possessions	1,314	338	11	4	58	11
Total (tons) ..	47,162	21,171	272	786	483	59
Value (£) ..	1,644,426	813,056	10,310	37,135	17,787	4,075
Total export and re-export (tons)	82,108	37,135	—	—	—	—

Lard.—The enormous imports of lard to the United Kingdom are almost entirely derived from the United States of America, from which country 104,676 tons (out of a total of 114,967 tons) was obtained in 1922; only 4,086 tons were obtained from British Possessions, of which 3,983 tons were from Canada and 102 tons from Australia. The vast majority of lard exported from the United Kingdom in 1913 represented re-exported material, and the total amount exported or re-exported in 1922 only amounts to a total of 707 tons, of which 440 tons were to the British Possessions (Channel Islands 132 tons, West Africa 38 tons, Malta and Gozo 178 tons).

The consumption of lard in the United Kingdom is obviously very large, and the only means of meeting the demand from Empire sources would be by increasing pig-farming in the United Kingdom or the Colonies. Pig-farming is apparently on the increase in the United Kingdom, but there is obviously room for expansion on a large scale, as the imports of bacon and allied products amount annually to a total of about £50,000,000.

Imitation Lard.—The imports of this material are comparatively small, and in 1913 were chiefly (9,233 tons of the total of 11,226 tons) from the United States; in 1922 the chief importers were the Netherlands, 1,309 tons; Belgium, 1,726; the United States, 1,537 tons. Small imports from Canada comprised the whole of the imports from British sources. The exports of imitation lard are too small to merit comment.

* Including vegetable tallow.
† 628 tons Australian.
‡ 1,211 tons refined animal oil, 2,568 unrefined.
§ All refined.
‖ 532 tons refined animal oil.

Grease, Crude Tallow, and Animal Fats.—The import figures refer to crude tallow,* and the following table shows the chief sources of imports of tallow:

Imports from:	1913 (*Tons*).	1922 (*Tons*).
China	5,583	204
United States	4,183	2,978
Uruguay	3,885	2,066
Argentine Republic	11,556	9,704
Other foreign countries	2,084	918
Australia	45,764	18,817
New Zealand	21,215	24,028
Other British sources	834	200
Percentage of total from British sources	71·3	75·0

Foreign imports of tallow in 1913 were principally drawn from South America, China being the next important source; since 1920 the quantities derived from China have been insignificant. Imports from Australia in recent years are much smaller than before the War. The average yearly imports from Australia during 1919-22 amount to about 17,400 tons compared with an average of over 43,000 tons for 1912 and 1913. The average yearly imports from New Zealand during 1919-22 are almost the same—20,550 tons—as in years before the War.

The following figures show the relationship between total imports of tallow, etc., compared with exports of home manufactured material and re-export of foreign merchandise before and since the War:

	1912† (*Tons*).	1913† (*Tons*).	1919† (*Tons*).	1920 (*Tons*).	1921 (*Tons*).	1922 (*Tons*).
Total imports	101,967	95,104	88,339	44,659	48,910	58,856
Approximate average				60,000		
Exports	29,393	34,946	28,891	18,787	16,971	15,964
Approximate average				20,000		
Re-exports	48,675	47,162	22,300	20,774	20,787	21,171
Approximate average				21,000		
Retained in United Kingdom (approximate)	24,000	13,000		19,000		

Although certain other materials are included under "tallow" prior to 1920, and an exact comparison of pre-war with post-war trade is not possible, it is obvious that there is a diminution in the trade in tallow since the War, and that the amounts of tallow retained for consumption in the United Kingdom vary considerably from year to year. Out of the total exports and re-exports of tallow in 1922, amounting to over 37,000 tons, only 1,020 tons were exported to British Possessions, the largest exports being those to India and Canada—viz., 555 and 129 tons respectively—the remainder being distributed in small quantities to various countries. The bulk of the export trade in tallow is to the Continent, the total amounts of tallow and other animal fats to the principal destinations in

* Prior to 1920 imports under this heading include stearine and vegetable tallow.

† Including vegetable tallow.

1922 being as follows: Italy 5,079, Germany 8,596, Netherlands 4,126, France 3,384, Belgium 3,452, Latvia 1,568, Poland 2,394 tons; while 2,211 tons were shipped to the United States. In 1913 Russia was the chief destination, with 24,964 tons out of a total export (including re-export) of over 82,000 tons.

Oleo-Margarine, Oleo-Oil, and Refined Tallow.—The imports of these refined animal oils for use in margarine and various edible fats are considerably larger in recent years than in 1913.

IMPORTS TO UNITED KINGDOM.

	1913.	1919.	1920.	1921.	1922.
From foreign countries	14,317	38,283	24,060	21,197	24,451
„ British Possessions	4,561	12,204	6,588	6,238	5,479
Total..	18,878	50,487	30,648	27,435	29,930

The chief sources of foreign supplies are the Argentine Republic and the United States of America; in 1922 the imports from these countries were 13,934 and 6,280 tons respectively. Supplies from British Possessions are almost entirely derived from Australia and New Zealand, which contributed 3,242 and 1,920 tons respectively in 1922. Canada also furnished some of these materials; 304 tons were derived from this source in 1922, and in 1919, 1,312 tons.

It should be possible to increase the imports of such materials from Australia and New Zealand, and to reduce imports from foreign sources, but it must be remembered that Argentine trade in these products is largely dependent on British capital, while the long distance between the United Kingdom and Australasia is a factor of importance influencing the cost of shipment and also the possible deterioration of goods during transit.

The export trade in these materials has averaged about 3,200 tons a year during the period 1919-22, compared with nearly 13,000 tons in 1913; only a small proportion, varying from 98 to 476 tons, has been shipped to British Possessions during 1919-22. Most of the exports are distributed between various Continental countries. India is the chief buyer among British Possessions, with 173 tons in 1922. The re-export trade is on a larger scale, chiefly to the Continent; only 442 tons in 1922 went to British Possessions.

Other Animal Oils and Fats.—There are, unfortunately, no records as to the exact nature of the materials included in the official statistics under the headings of refined and non-refined animal oils and fats, and "other sorts," which comprise the totals quoted under the heading of "other animal oils and fats" in the table on p. 160, but such materials as lard oil, neat's-foot oil, and various animal oils of minor importance will be included. The imports in 1913 all refer to animal oil, the chief sources of supply being the United States with 7,410 tons, the remainder is chiefly derived from the Continent (mainly from the Netherlands, 1,089 tons, and Belgium, 1,085 tons). In 1922 out of the total of 3,779 tons, 1,211 tons are refined animal oil "other sorts" (*i.e.*, excluding lard, oleo-margarine, oleo-oil, and refined tallow); the remainder, 2,568 tons, is unrefined. The chief sources are United States, 1,169 tons, Argentine and Uruguay, 1,163 tons; while of the total import from British

Possessions 628 tons is of Australian origin. The exports and re-exports only total 1,697 tons in 1922, of which 1,443 tons is refined material. Exports to British Possessions are insignificant—59 tons—the bulk being shipped to the Continent (Netherlands 347 tons, Belgium 317, Germany 100 tons).

Stearine.—The material referred to commercially as stearine is in reality commercial stearic acid manufactured generally from tallow, by splitting and distillation (see p. 27), and is employed in candle manufacture. The largest imports during 1922 are those from the United States of America and the Argentine Republic—803 and 806 tons respectively; that from Belgium is only 458 tons, compared with an average of 1,666 tons a year from 1912 to 1914. Of the total import of stearine in 1922, 442 tons were derived from British Possessions, chiefly from Australia, 376 tons, and Canada, 46 tons.

Group 3.—Fish and Marine Animal Oils.

An exact comparison of the trade in these oils before the War and in recent years is not possible, owing to the fact that detailed statistics are not available before 1920.*

FISH AND MARINE ANIMAL OILS: IMPORTS TO THE UNITED KINGDOM (TONS).

Principal Sources.	*All Kinds, including Fish, Seal, Whale, Sperm-Head Matter.* 1913.	1919.	1922. *Whale.*	*Cod Liver.*	*Other Sorts.*
Norway	5,664	17	10,969	1,450	26
Iceland and Greenland	1,258	361	—	48	405
French West Africa	3,951	—	—	—	—
Portuguese West Africa	5,422	—	—	—	—
Japan, etc.	5,055	4,248	127	—	1,277
United States of America	1,552	3,297	1,001	—	3
Chile	2,101	—	—	—	—
Argentine Republic	1,908	480	—	—	—
Whale fisheries:					
Northern	798	—	340	—	—
Southern	8,509	17,297	—	—	—
Other countries	4,562	1,005	7,849†	95	523‡
Total (foreign countries)	40,800	26,705	20,283	1,593	2,234
Cape of Good Hope	6,115	3,023	606	—	—
Natal	5,594	554			
Canada	3,713	293	567	—	—
Newfoundland and Labrador	5,285	3,681	—	—	240
Falkland Islands	8,500	20,200	6,519§	—	50
Other British Possessions	879	319	412	—	77
Total (British Possessions)	30,086	28,070	8,104	698	367
Total	70,886	54,775	28,387	2,291	2,601
Value (£)	1,508,416	3,784,162	1,013,535	90,123	72,018

* Imports of fish, seal, whale, and cod-liver oil, etc., were included under one heading in the official trade returns, while exports were included in "oils, unenumerated."

† Including Netherlands, 5,919 tons; Spain, 1,453 tons.

‡ Portugal, 273 tons. § 1920, 19,643 tons.

The total imports of these oils in 1913, 1919, and 1922 are, therefore, as follows:

	1913.	1919.	1922.
Total imports (tons)	70,886	54,775	33,279
From British Possessions (tons) ..	30,086	28,070	9,069

Imports from the foreign countries in 1913 and 1919 are probably largely whale oil, as in 1922; thus the imports derived from French and Portuguese West Africa, Chile, and the Argentine Republic no doubt represent this oil alone. Imports from Japan are partly fish oil and also whale oil; those from Norway will include cod-liver oil and herring oil, in addition to whale oil. The imports from southern whale fisheries no doubt refer to the produce of South Georgia whale fisheries. Imports from the United States will include some menhaden oil, which is produced in large quantities in that country.

Imports of whale oil in 1922 from foreign countries amounting to 20,283 tons were largely obtained from Norway, though much of this is no doubt the produce of the South Georgia whale fishery (see p. 106), in which several Norwegian firms are engaged. The quantity recorded from the Netherlands—5,919 tons—is also no doubt re-exported.

With regard to whale oil from British sources, it is evident that the whale fisheries of South Africa (see p. 106) are much less productive in recent years. In 1913, 11,709 tons were imported from this source; in 1922 the import has fallen to 606 tons, the highest recent import from this source being 5,786 tons in 1920.

	1913 (*Tons*).		1922 (*Tons*).	
	Re-Exports.	*Exports.*	*Re-Exports.*	*Exports.*
Whale oil:				
To foreign countries	5,734	*	2,690	6,240
,, British Possessions	62	—	—	68
Total	5,796		2,690	6,308
Cod-liver oil:				
To foreign countries	Included above		66	1,373
,, British Possessions	—		50	160
Total	—		116	1,533
Other sorts:				
To foreign countries	Included above		618	2,346
,, British Possessions	—		1	402
Total	—	—	619	2,748
Total (tons)	5,796	—	3,425	10,589
Value (£)	121,360	—	106,894	395,291

* Included with "oil, etc., unenumerated" in United Kingdom statistical tables.

The apparent decrease in import from the Falkland Islands is partly due to the re-export from Norway noted above, and also to increasing direct imports to the United States.

Cod-liver oil in recent years is mainly derived from Norway; the amounts imported from Newfoundland are not recorded in the trade returns of the United Kingdom, although Newfoundland produces a considerable quantity of cod-liver oil (see p. 103), and Newfoundland oil is regularly quoted on the English markets.

The exports and re-exports of fish, whale, and other marine animal oils are as on p. 164.

Practically the whole of this oil exported or re-exported goes to the Continent, the chief importers being generally the Netherlands, Germany, and Belgium.

The exports to British Possessions are small, the total only amounting to 681 tons in 1922, of which 350 tons were shipped to Australia (134 tons of cod-liver oil, 206 tons other kinds) and 85 tons to India.

Oilcakes.

The table below shows the imports and exports of oilcakes of all kinds in 1913 and in 1922.

Cotton-seed and linseed cakes have been manufactured and used for feeding cattle and other animals in very large quantities for many years past; soya-bean cake only became of importance after soya beans began to be worked in large quantities in the United Kingdom; rape-seed cake is not popular as a feeding cake in this country, but no doubt enters frequently into "compound cake," and is largely used as a manure; the use of ground-nut cake in large quantity is also of fairly recent origin.

IMPORTS, EXPORTS, AND RE-EXPORTS OF OILCAKES TO UNITED KINGDOM.

IMPORTS (1913).

Kind of Cake.	*From Foreign Countries (Tons).*	*From British Possessions (Tons).*	*Total Quantity (Tons).*	*Total Value (£).*
Linseed	50,647	33,032	83,679	626,118
Cotton seed	227,322*	9,401	236,723	1,407,023
Rape seed	28,859	23	28,882	156,592
Ground nut and soya bean ..	Included in other cake		—	—
Other kinds	20,764	36,652	57,416	350,159
Total	327,592	79,108	406,700	2,539,892

IMPORTS (1922).

Kind of Cake.	*From Foreign Countries (Tons).*	*From British Possessions (Tons).*	*Total Quantity (Tons).*	*Total Value (£).*
Linseed	30,915	17,824	48,739	637,122
Cotton seed	60,910†	113,057‡	173,967	1,599,635
Rape seed	10,661	7	10,668	80,168
Ground nut and soya bean ..	367	—	367	4,054
Other kinds	29,574	5,087	34,661	266,103
Total	144,034	183,887	327,921	3,142,527

* Including Egypt, 58,815 tons. † Excluding Egypt. ‡ Including Egypt, 109,912 tons.

IMPORTS, EXPORTS, AND RE-EXPORTS OF OILCAKES TO UNITED KINGDOM—*Continued.*

EXPORTS AND RE-EXPORTS (1913).

Kind of Cake.		To Foreign Countries (Tons).	To British Possessions (Tons).	Total Quantity (Tons).	Total Value (£).
Linseed	Export	5,982	167	6,149	47,394
	Re-export	1,277	9	1,286	10,293
Cotton	Export	7,718	44	7,764	36,638
	Re-export	230	5	235	1,436
Rape	Export	965	5	970	5,120
	Re-export	—	—	—	—
Ground nut ..	Export	Included in other cake		—	—
	Re-export				
Soya bean ..	Export	29,901	2	29,903	208,899
	Re-export	—	—	—	—
Other kinds ..	Export	8,647	17	8,664	56,292
	Re-export	1,337	—	1,337	9,495
Total	(*a*) Export	53,213	235	53,448	354,344
	(*b*) Re-export	2,844	14	2,854	21,224
„ (*a*)+(*b*)		56,057	249	56,302	375,568

EXPORTS AND RE-EXPORTS (1922).

Kind of Cake.		To Foreign Countries (Tons).	To British Possessions (Tons).	Total Quantity (Tons).	Total Value (£).
Linseed	Export	8,478	344	8,822	113,989
	Re-export	1,975	8	1,983	26,801
Cotton	Export	3,616	202	3,818	28,867
	Re-export	1,499	1	1,500	17,599
Rape	Export	529	—	529	3,940
	Re-export	—	—	—	—
Ground nut ..	Export	205	19	224	2,058
	Re-export	1,522	—	1,522	12,668
Soya bean ..	Export	4,172	—	4,172	48,839
	Re-export	—	—	—	—
Other kinds ..	Export	24,393	184	24,577	186,420
	Re-export	6,550	—	6,550	54,788
Total	(*a*) Export	41,393	749	42,142	384,113
	(*b*) Re-export	11,746	9	11,755	111,856
„ (*a*)+(*b*)		53,139	758	53,897	495,969

Although coconut and palm-kernel cakes have been produced in the United Kingdom in increasing quantities, and are also imported to this country, they do not appear under a separate heading in the statistical tables.

It is difficult to arrive at an estimate of the average annual consumption of cake in this country, but the consumption is very large, as may be judged from a con-

sideration of the figures for 1922 given below for (1) imports of cake, less exports and re-exports, and (2) cake equivalent* to oilseed imports, less re-exports.

	1922 (*Tons*).
Oilcake:	
A. Total imports	327,921
B. Exports and re-exports	53,897
1. Difference A-B	274,024
Oilseeds:	
Imports, less re-exports	1,326,925
2. Equivalent to oil-cake	940,392

Estimated consumption 1+2=1,214,416 tons.

In comparing the total imports of oilcakes in 1913 and 1922, it is of interest to note that, though the total imports in the latter year are considerably less than in the former, the proportion of imports derived from British sources is considerably increased. The chief factor in this is the greatly increased import of cotton-seed cake from Egypt. In 1913 Egypt was included in the official trade returns with foreign countries and imported 58,815 tons; in 1922 Egypt was included with British Possessions and imported 113,057 tons. The following table serves to indicate the effect of making allowance for this alteration in the official figures:

	Total Imports (*Tons*).	Per Cent. Derived from— Foreign Countries.	British Possessions.
1913—Imports from:			
Foreign countries, Egypt included	327,592	80·5	19·5
British Possessions, Egypt excluded ..	79,108		
Foreign countries, Egypt excluded	268,777	66	34
British Possessions, Egypt included ..	137,923		
1922—Imports from:			
Foreign countries, Egypt excluded	144,034	44	56
British Possessions, Egypt included ..	183,887		

With regard to the sources from which imports of the different kinds of oilcakes are derived, these may be most conveniently considered separately.

Linseed cake, obtained from foreign sources, is chiefly from the United States of America, the imports being 24,837 tons in 1913, and varying from 20,360 tons (1922) to 43,112 tons in 1919, over the period 1919-22. In 1913, 18,747 tons were shipped to the United Kingdom from Russia; no imports have been obtained from this source since 1919. The only other important foreign sources are the Argentine Republic—2,318 tons in 1913, 10,266 tons in 1921, and 5,351 tons in 1922—and Spain, which supplied 2,741 tons in 1922.

The imports of linseed cake from different British Possessions in 1913 and from 1919 to 1922 are as follows:

* See p. 140.

LINSEED CAKE IMPORTS TO UNITED KINGDOM (TONS).

	1913.	1919.	1920.	1921.	1922.
From British India	17,606	14,310	10,413	10,205	10,312
„ Australia	11	50	2,429	7,820	4,462
„ Canada	15,233	10,165	1,423	2,039	2,927
„ other sources	182	59	75	45	123
Total	33,032	24,584	14,340	20,109	17,824
For comparison, total foreign imports	50,647	46,668	29,959	39,122	30,915

Annual imports from British India since 1919 are, therefore, less than in 1913, while imports from Canada in 1922 have dropped to about one-fifth of that in 1913, no doubt owing to the importation of the bulk of the Canadian linseed crop to the United States. The imports from Australia, which are insignificant in 1913, have become of some importance in recent years.

Exports of home manufactured linseed cake in 1922 are the largest since 1919, practically the whole being shipped to Denmark, the Netherlands, and France (in 1922, 3,741, 2,648, and 1,880 tons respectively); while out of 1,975 tons of re-exported cake 1,372 tons were shipped to Belgium and the remainder to the Netherlands. Of the small export to British Possessions 334 tons were shipped to the Channel Islands.

Cotton-Seed Cake.—The imports of cotton-seed cake since 1919 are considerably less than in pre-war years, as is shown in the following table, which also indicates the principal sources of supplies and the growing importance of imports from Egypt.

COTTON-SEED CAKE IMPORTS (TONS).

Imports from principal foreign sources:	1913.	1919.	1920.	1921.	1922.
Germany	71,040	—	—	—	—
United States of America	74,195	108,858	10,561	48,467	40,299
France	3,040	615	—	—	—
Mexico	3,086	200	55	—	93
Peru	6,427	4,141	5,891	11,947	12,429
Chile	—	8,276	200	1,484	76
Brazil	4,900	12,696	4,632	2,141	3,685
Total from foreign sources	168,507	135,578	21,932	67,781	60,910
From British sources:					
Egypt	58,815	56,475	80,845	90,366	109,912
British East Indies	8,964	3,456	7,776	3,094	2,567
Total from British sources	68,216	63,348	88,638	93,741	103,057

The reduced imports from North America are of interest and are due largely to reduction in yield of cotton crop in recent years; in 1913-14 the cotton crop amounted to 14,156,000 bales of cotton (500 pounds); in 1921-22 and 1922-23 the crops were only 7,954,000 and 9,762,000 bales respectively.

The exports and re-exports of cotton-seed cake in 1922 are very small in relation to the imports and to production of this cake in the United Kingdom, but are of interest as an indication of the enormous home consumption of this cake.

Imports of *rape-seed cake*, prior to the War, were mainly derived from Russia, from which source 25,839 tons of the total import of 28,882 tons in 1913 was obtained. In 1922 the imports are less than a half of those in 1913, and more than one-half—5,960 tons—was from the Netherlands, together with about 1,500 tons each from Italy, the Argentine Republic, and " other foreign countries."

The exports are too small to need comment.

No details are available relating to imports of *ground-nut cake* before 1920. In recent years a very large proportion of the imports have been from British India. The following table indicates the relative proportions from British and foreign sources.

	1920 (*Tons*).	1921 (*Tons*).	1922 (*Tons*).
Imports from British India	24,407	36,325	47,654
Total from British sources	25,565	36,935	47,912
Total from foreign sources	1,999	8,954	11,607

In 1922, 3,955 tons were from France, 1,943 tons from Spain, and 3,830 from the Argentine Republic. The exports of ground-nut cake are small; in 1922 out of a total export and re-export of 2,058 tons, 1,522 tons were shipped to Germany. The home consumption of ground-nut cake is evidently very considerable.

Imports of *soya-bean cake* are quite insignificant, while exports only amount to a total of 4,172 tons in 1922 (this being the largest export since 1919), compared with nearly 30,000 tons in 1913. The chief foreign buyer of English soya-bean cake both before and since the War has been Denmark, which country took 15,490 tons in 1913 and 2,969 tons in 1922.

An idea of the total consumption of soya-bean cake in the United Kingdom is indicated by the following figures, though it must be remembered that such estimates are influenced to an unknown degree by the use of soya cake in compound cake exported under " other kinds."

IMPORTS OF SOYA BEANS AND CAKE (TONS).

	1913.	1919.	1920.	1921.	1922.
1. Imports of soya beans, less exports	75,649	61,565	7,255	60,341	58,556
2. Cake equivalent*	62,000	50,400	5,940	49,400	46,800
3. Imports of cake	Not recorded		13	5	367
4. Total 2+3	62,000	50,400	5,953	49,405	47,167
5. Exports of cake	29,903	—	450	489	4,172
6. Approximate consumption ..	32,097	50,400	5,503	48,916	42,995

The heading " *other kinds* " will include coconut and palm-kernel cakes and compound cakes.

* See p. 140.

The principal imports for 1922 are as follows:

	1922 (Tons).	Probably Chiefly.
Imports of oilcakes, "other kinds," from:		
Netherlands	3,626	—
Java	5,354	Coconut cake
Japan	3,450	—
Philippine Islands	7,934	Coconut cake
Argentine Republic	1,893	—
Total foreign countries	29,574	—
India	1,759	—
Straits Settlements	1,375	Coconut cake
Canada	1,096	—
Total from British Possessions	5,087	—

It would therefore seem that at least 14,909 tons of coconut cake is included in the above total import of "other kinds" of oilcake. The majority of the exports of these unclassified oilcakes is shipped to the Continent, chiefly to Belgium, the Netherlands, and Germany.

Resins.

No resins are produced in the country other than artificial or synthetic resins; the whole of the large demand for resins for varnish manufacture and for other purposes has, therefore, to be met by importation from various sources. The table on p. 171 shows the total quantities and values of various resins imported to the United Kingdom in 1913 and in 1922.

From the figures it will be seen that the imports of resins in 1922 were less than in 1913 by nearly 635,000 hundredweights, but that the value of imports in 1922 was £385,732 greater than in 1913. The most noticeable decrease in import is that of kauri resin from New Zealand, the imports in 1922 being less than one-third of those in 1913, although the figures do not indicate any appreciable decrease in value per hundredweight. Rosin shows a decrease of nearly 500,000 hundredweights, lac-resin imports are less in 1922 than in 1913 by about 17,000 hundredweights, but the value per hundredweight has increased enormously.

With regard to copal, it is unfortunate that detailed statistics of sources of imports are not available before 1920, but consideration of the 1922 figures shows that only 27,295 hundredweights out of a total import of 164,170 hundredweights was obtained from British Possessions, or approximately 17 per cent.

The great majority of this—25,416 hundredweights—came from the Straits Settlements, and no doubt represents very largely material shipped through Singapore and produced in the Dutch East Indies, such as "Macassar" copal.

IMPORTS OF RESINS TO UNITED KINGDOM.

	1913. Quantity (Cwts.).	1913. Value (£).	1922. Quantity (Cwts.).	1922. Value (£).
Copal from:				
British Possessions	Included in "other		27,295	62,428
Foreign countries	sorts"		136,875	254,618
Total	—	—	164,170	317,046
Kauri from:				
British Possessions	144,188	599,741	40,398	170,687
Foreign countries	1,445	3,110	135	862
Total	145,633	602,851	40,533	171,549
Rosin from:				
British Possessions	27,035	12,357	5,753	4,398
Foreign countries	1,731,032	1,108,295	1,266,656	879,317
Total	1,758,067	1,120,652	1,272,409	883,715
Lac-resin (principally shellac) from:				
British Possessions	107,020	411,781	84,202	1,454,928
Foreign countries	1,719	6,666	7,445	110,207
Total	108,739	418,447	91,647	1,565,135
Other sorts (including copal in 1913) from:				
British Possessions	67,535	135,498	27,209	77,798
Foreign countries	162,065	392,588	11,334	40,525
Total	229,600	528,086	38,543	118,323
Total from all sources	2,242,039	2,670,036	1,607,302	3,055,768
Total from British Possessions ..	345,778	1,159,377	184,857	1,770,239

Copal from foreign sources was largely—87,116 hundredweights out of 136,875 hundredweights—imported through Belgium, probably mostly Congo copal; 11,880 hundredweights came from the Belgian Congo, and the quantity of 30,000 hundredweights imported, partly direct from Java and other Dutch Indian Possessions and partly through the Netherlands, will represent "Macassar copal," largely.

Fair quantities of copal are exported from the United Kingdom—principally to the Continent—but the great bulk of that imported is consumed in home manufactures.

With regard to "kauri," this is practically entirely the produce of New Zealand. The decrease in the imports of "kauri" to the United Kingdom in recent years is very remarkable; the imports from 1919 to 1922 only varied from 30,807 hundredweights in 1919 to 40,398 in 1922, compared with 144,188 hundredweights in 1913.

Although large amounts of kauri resin are employed in the United Kingdom, the exports represent a fairly large proportion of the quantities imported; this was particularly noticeable in 1913, when the export amounted to 105,105 hundredweights compared with 145,633 hundredweights imported; of this export over 57,500 hundredweights went to the United States of America. From 1919 to 1922 the quantities exported are much smaller, the largest export being that of 1922—viz., 14,637 hundredweights, principally to Continental countries, Germany being the largest buyer. The decrease in imports to the United Kingdom and re-exports to the United States is largely due to direct consignments from New Zealand to the United States.

The United Kingdom imports of rosin are almost entirely derived from foreign sources, chiefly the United States of America, from which source over 75 per cent. was obtained in 1913 and a little under 50 per cent. in 1922. The most important other source is France, from which country a little over 10 per cent. of the quantity imported in 1919 was obtained and about 16 per cent. in 1922. Both Spain and Portugal also contribute a certain amount of rosin, the imports from these sources in 1922 being 57,933 and 96,088 hundredweights respectively. (In 1919, 121,484 hundredweights were imported from Spain.)

Probably the only sources within the Empire from which Great Britain might obtain rosin (and turpentine) in any quantity are British Honduras and India. In India the production of rosin has steadily increased during recent years. Up to the present it does not appear that any appreciable exportable surplus has been available; increased exploitation in the future should lead to considerable exports, and supplies to the United Kingdom and other parts of the Empire may be anticipated, though there appears to be a good market for Indian rosin in Java (see p. 195).

In British Honduras large areas of pine trees exist, but no serious attempt appears to have been made up to the present to exploit these for rosin and turpentine. Of the rosin imported to the United Kingdom only a very small proportion is re-exported as a rule; thus, the exports in 1922 only amounted to 49,951 hundredweights (compare total imports, 1,272,409 hundredweights), over three-fifths of the re-export of this being to British Possessions—chiefly to South Africa, 7,686; India, 9,931; Australia, 3,342; and New Zealand, 7,292 hundredweights; though re-exports to foreign countries were larger in 1913 and 1919 than those to British Possessions. Over the period 1919-22 the average annual consumption of rosin amounts to over 1,476,500 hundredweights.

SHELLAC.

The importation of lac-resin to Great Britain is very considerable; over 108,700 hundredweights were imported in 1913, and the quantity has only varied from 78,850 to 95,305 hundredweights between 1919 and 1922. Practically the whole of this is furnished by India, though it is of interest to note that 1,640 hundredweights came from Siam in 1922, and 4,389 hundredweights from the United States of America, though undoubtedly the latter quantity represents re-exports. The most noteworthy feature is the great increase in value of lac-

resin: in 1913 the average value (worked out from the statistical figures) is a little over 76s. per hundredweight; in 1922 the value is over 340s. per hundredweight.

These values are, of course, only approximate, being derived from the statistical figures, but it is of interest to note that T.N. shellac sold in London during 1913 at prices around 80s. per hundredweight; in January, 1923, the spot price was 300s. per hundredweight in London (see p. 125).

In spite of the high prices which have ruled since the War, the intrinsic qualities of lac-resin are such as to render its use essential in many manufactures, and there appears to be no diminution in the demand.

It is difficult to obtain an accurate estimate of the amount of lac-resin required for consumption in the United Kingdom, but that this quantity is very considerable is evident on comparing the quantities imported and exported.

UNITED KINGDOM: IMPORTS AND EXPORTS (CWTS.).

	1913.	1919.	1920.	1921.	1922.
Imports	108,739	95,305	83,371	78,850	91,647
Exports	51,590	74,869	43,287	52,786	50,766
Difference (imports less exports)	57,449	20,436	40,084	26,064	40,881
Exports to British Possessions ..	125	1,853*	1,371	345	430
Foreign countries	51,465	73,016	41,916	52,441	50,336

The majority of the lac-resin exported goes to the Continent (Germany and France being the chief buyers as a rule) and to the United States. Of the exports in 1922, 6,534 hundredweights were to Germany, 6,265 hundredweights to France, and 23,322 to the United States. It is of interest to note that, in 1919, 13,002 hundredweights were exported to France, 39,311 hundredweights to the United States, and that the quantity exported to Germany—viz., 16,823 hundredweights—is a little more than in 1913 (16,650 hundredweights).

The importance of the London market in the lac-resin is obvious, a large proportion of the supplies to the Continent passing through this market, though a fair quantity of lac is exported direct from India to the Continent. The quantities of shellac imported to the United States through the New York market are, however, far larger than those imported to Great Britain (see p. 192).

RESINS—"OTHER SORTS."

With regard to resins classified as "other sorts" in the United Kingdom trade returns, these included copal up to the end of 1919, and a large proportion of the total import for that year will represent "Congo," "Macassar," and "Zanzibar" copal, as well as a certain amount from British West Africa (some idea of the quantity from the latter source will be seen from figures under British West African Colonies). In 1922 the only imports over 1,000 hundredweights from foreign countries were as follows: Netherlands, 1,476; Java and Dutch

* To Canada, 1,682 cwts.

Indies, 2,072; France, 3,437; Morocco, 1,435 hundredweights. The Netherlands, Java, etc., imports are probably dammar from the Dutch East Indies; the import from France will no doubt represent re-export, probably copal; while the Morocco import is probably sandarac or/and mastic.

In 1922 resins of "other sorts" imported to the United Kingdom amounted to 27,209 hundredweights; the following table shows the sources of these imports, with notes on the probable nature of the materials.

IMPORTS, 1922.

	Cwts.	Probable Nature.
From Zanzibar and Permba	2,557	Almost certainly East African copal.
" Sudan	3,439	Probably frankincense or olibanum.
" British India	7,349	Uncertain; dammar (?) and various minor resins.
" Straits Settlements	1,439	Probably all dammar.
" Australia	11,394	Acaroid resin.
" Other British Possessions.. ..	1,031	—
Total	27,209	

WAXES.

A certain small amount of beeswax is produced in the United Kingdom, but compared with the amount consumed this quantity is negligible. It is, unfortunately, not possible to quote detailed figures for imports before 1920, but the following data for imports of beeswax and carnauba and other vegetable waxes (excluding waxes of mineral origin) will convey an idea of the demand for such waxes in the United Kingdom, and the sources from which they are obtained:

IMPORTS TO UNITED KINGDOM (CWTS.).

	Beeswax.			Carnauba and Other Vegetable Waxes.		
	1920.	1921.	1922.	1920.	1921.	1922.
From British Possessions* ..	10,121	4,580	8,086	362	—.	—
Total from British Possessions and foreign countries ..	33,561	10,685	24,937	29,253	25,582	37,254
Total value (£)	301,168	59,196	126,604	336,688	131,949	158,456

In the case of beeswax, approximately one-third of the imports is derived from the British Empire, by far the most important source being British East Africa, which contributed 4,538 of the total of 8,086 hundredweights in 1922, while Egypt, the Sudan, India, Aden and dependencies, each contributed from 761 to 953 hundredweights. Among foreign importers in 1922 the most important was Portugal with 4,137 hundredweights, followed by French West Africa, 2,499; France, 2,439; Chile, 1,661; Portuguese East Africa, 1,270 hundredweights.

* Egypt included.

There is no reason why the demand for beeswax in the United Kingdom should not be met entirely from Empire resources, particularly by the East and West African Colonies, and India.

With regard to imports of "carnauba and other vegetable waxes," it is evident that this is very largely carnauba wax, as the imports from Brazil (the only commercial source) generally form about two-thirds of the total; thus in 1922, out of a total of 37,254 hundredweights for vegetable waxes, the imports were as follows: from France, 1,081; Japan (etc.), 6,274; United States of America, 5,657; Chile, 1,174; Brazil, 21,143 hundredweights. In some cases—*e.g.*, France—the imports most likely represent re-exports of carnauba wax; the import from Japan almost certainly represents what is known as "Japan wax," which is in reality not a wax from the chemical standpoint, but a hard fat (see p. 98).

It is impossible to ascertain definitely the nature of the imports (1,174 hundredweights) of wax (other than beeswax) from Chile; very probably this is carnauba wax or a wax closely resembling this which is derived from another palm, *Ceroxylon andicola*, known to occur in certain parts of South America—*e.g.*, in Colombia. The wax imported from America is likely to be largely candelilla wax, which has been produced in considerable quantities in the southern parts of the North American continent, and which appears in the United Kingdom markets.

The exports and re-exports of beeswax and of carnauba and other waxes from the United Kingdom in recent years are as follows:

	1920.		1921.		1922.	
	Re-Exports (*Cwts.*).	*Exports* (*Cwts.*).	*Re-Exports* (*Cwts.*).	*Exports* (*Cwts*)	*Re-Exports* (*Cwts.*).	*Exports* (*Cwts.*).
Beeswax to:						
Foreign countries ..	17,901	1,279	14,109	1,016	4,563	1,648
British Possessions ..	3,334	102	179	1,115	926	2,728
Total (cwts.) ..	21,235	1,381	14,288	2,131	5,489	4,376
Value (£)	178,181	13,732	61,153	10,603	25,196	24,463
Carnauba and other waxes to:						
Foreign countries ..	20,244	—	11,694	—	4,727	—
British Possessions ..	1,123	—	1,005	—	1,698	—
Total (cwts.) ..	21,367	—	12,699	—	6,425	—

It is not possible to gain any accurate idea of the yearly requirements of the United Kingdom for beeswax from a consideration of the rather scanty details available. The exports of beeswax show wide fluctuations during 1920-22, and in one year (1921) re-exports were in excess of imports.

With regard to exports recorded under produce and manufactures of the United Kingdom, it is probable that these consist to a fair extent of wax imported

in a more or less crude state, and refined or bleached before export from the United Kingdom. Much of the re-exported beeswax goes to the Continent, chiefly to Germany, Belgium, and the Netherlands, to which countries 2,125, 1,451, and 2,829 hundredweights were exported respectively in 1920, while exports to the United States of America amounted to 6,573, 2,026, and 1,249 hundredweights respectively in the three years under consideration. In 1922 332 hundredweights were exported to Canada and 594 to other parts of the Empire; in 1920, 3,306 hundredweights went to Canada.

In connection with carnauba and other waxes it is of interest to compare imports and re-exports.

	1920 (*Cwts.*).	1921 (*Cwts.*).	1922 (*Cwts.*).
Total imports	29,253	25,582	37,254
Total re-exports	21,367	12,699	6,425
Difference (imports less re-exports)	7,886	12,883	31,829
Re-exports to:			
British Possessions	1,123	1,005	1,698
Foreign countries	20,244	11,694	4,727

As far as can be seen from the statistics relating to the short period under consideration, the demand for carnauba and other vegetable waxes in the United Kingdom is fairly large, and is on the increase, though a good deal is reshipped to the Continent, chiefly to Germany, France, and Italy, and also to the United States. The majority of the wax re-exported to British Possessions went to Australia (1,406 hundredweights in 1922).

ASIA

CYPRUS

CYPRUS is the third largest island in the Mediterranean, and is 100 miles long and 30 to 60 miles broad. The area of cultivated land is approximately 1,200,000 acres, or rather more than half the total area of the island. Agriculture is the main industry, and the island is well situated for the markets of Egypt, Syria, and Asia Minor. The climate shows considerable extremes, the summer temperature ranging between 80° to 110° F., while frosts are liable to occur in winter. The prosperity of the island depends on the winter rainfall, and a satisfactory solution of the water problem would be of enormous assistance to agriculture. The most important oil crops cultivated are olives, sesame, ground nut, castor, and cotton.

The olive tree grows wild and only requires grafting and cleaning in order to bear fruit, but considerable difficulty has occurred in the past in obtaining satisfactory grafts. The olives of Cyprus are divided into two main classes, the "adrouppes," used for eating, and the "ladœlies," used both for eating and oil extraction. The Agricultural Department of Cyprus has experienced great difficulty in inducing the natives to manure and prune the trees, but owing to the very satisfactory results obtained when applied, pruning at least is gradually becoming more common. The oil is obtained from the olives by crude native methods, and often possesses a strong flavour only appreciated by the inhabitants. A good deal of oil remains in the residue after pressing, which is to a large extent wasted. Where the small filters introduced by the Agricultural Department have come into use a greatly superior oil is produced of a more delicate flavour, which, however, is not appreciated by local consumers.

Large numbers of young wild trees are issued on permit from the State forests for cultivation, and many two to three year old plants are raised in the Government Nurseries; it seems probable that as these newly planted trees gradually come into bearing production may soon outgrow local demand, and an export trade be built up. This is borne out by recent figures. In 1920 the production of olive oil was estimated at 11,572 tons and in 1921 at only 412, and the imports for these years were respectively 123 and 6 tons. In 1922 only 2 tons of oil were imported and 47 tons exported.

The cotton industry has very much declined since it reached its maximum in 1866, and the total area under cotton is given for 1921 as 6,564 acres, yielding 1,029 tons of seed. Formerly about three-quarters of the cotton seed produced was exported, but exports in 1921 were only 88 tons.

Linseed is produced to some extent, and exports have for many years been at a fairly constant level, although the 1922 exports were the biggest since 1918. The seed is not usually properly winnowed or cleaned, and for this reason has

not in the past fetched the best prices. The properly cleaned seed, however, is of excellent quality.

EXPORTS OF LINSEED.

Year.	Tons.	Year.	Tons.
1913	284	1921	284
1919	367	1922	403 (to France, Egypt, and United Kingdom).
1920	267		

Linseed oil is not produced in sufficient quantity to satisfy home consumption, and in 1922, 28 tons were imported.

Sesame has long been one of the recognized summer crops in the plains, and the seed produced is used for the extraction of the oil and also in sweetmeats. The crop, however, is uncertain, being much affected by the hot west wind. In 1922, 144 tons of seed were exported.

Ground nuts are imported through Egypt, and efforts have been made to induce local cultivators to grow the crop, but so far without marked success, although, owing to the fear of introduction of plant pests, importation of the nuts, except in roasted condition, was for a time prohibited. Imports in 1922 reached 582 tons. In 1923 some 48 acres were under this crop, and the ground nuts produced are said to be of excellent quality.

The castor-oil plant is not extensively grown, but where it is grown thrives well; and attains the dimensions of a tree, and there seems scope for its further development.

INDIA AND BURMA

OILSEEDS, OILS, AND OILCAKES.

India is one of the most important countries of the British Empire from the point of view of production of raw material. It does not comprise such a big area as Australia or Canada, but the population is very much denser, averaging 226·1 to the square mile, whereas the average for the Commonwealth of Australia is 1·9 per square mile, and for Canada 2·42.

The great majority of the important oilseeds of commerce require a tropical climate for their full development, and in this respect India occupies a unique geographical position in the British Empire, for more than half the country lies in the tropical zone, and this, of course, has a profound influence on the agricultural development. The total area of India is some 1,093,074 square miles, which is roughly nine times that of the British Isles, and when it is considered that about one-twenty-seventh of this area is under oleaginous crops, including cotton, some idea of the magnitude of the industry may be gained.

The total yield of oilseeds is probably well over 5 million tons a year, of a value of, say, 75 million pounds, but as a large proportion is consumed in the country accurate figures for total production are impossible to obtain.

In most parts of India there are three well-marked seasons, the rainy (June to October), the cold (November to February), and the hot season (March to

May), but this alone does not determine the particular crops grown, for the relative dampness and dryness must also be considered.

Generally speaking, the climate in Southern India is uniformly warm and more humid on the west than the east; in Northern India much greater climatic variations occur, and only the hardier crops, such as rape and linseed, are grown. Sesame and ground nut are not extensively planted north of 20 degrees latitude, while the hardier rape and mustard flourish even in the Punjab. The influence of climate is also seen on the castor plant, which grows to a considerably larger size in the more southerly districts.

Oil crops are not of much importance in the mountainous northern provinces, although attempts are being made to cultivate olive trees, and it is possible that an olive industry may, in time, be established. Taken as a whole, elaborate methods are not practised in the cultivation of oilseed crops in India, but crop rotation is practised, and, to a certain extent, manuring. The introduction of the most suitable kinds of seed for each crop is receiving much more attention than was formerly the case, and the Agricultural Departments of the various provinces usually have experimental stations in which the best varieties of seed for the particular districts are determined, and also the best conditions for growth and harvesting. Usually, also, work on the pests affecting the various crops is undertaken and propaganda on the subject distributed to the farmers.

The most important of India's oilseeds are cotton, linseed, rape and mustard, ground nut, sesame, and coconut. Poppy, castor, niger, and safflower seed are also grown to a considerable extent. Various wild plants or trees also furnish oilseeds, the most important of these from a commercial standpoint being mowra, while mention may be made of others, such as the various species of *Myristica*, *Vateria indica*, which yields "Malabar tallow," and *Garcinia indica*, which produces "Kokum butter."

It is very difficult to obtain any clear idea as to the total production of India's oilseed crops, for consumption in India is on a large scale, and only the areas under the principal crops are considered in the official records. The acreage under the five principal crops is recorded in the following table, together with the estimated total production and chief provinces where each is grown:

Areas under the Principal Crops in 1922–23.

	Acres.		*Tons.*
Ground nut	2,530,000,	with average estimated out-turn of	1,157,000
Sesame	5,000,000,	,, ,, ,,	486,000
Cotton	21,176,000	(approximate)	1,714,000
Rape and mustard	6,213,000,	with average estimated out-turn of	1,213,000
Linseed	3,358,000,	,, ,, ,,	532,000

These crops are distributed as follows:

Ground Nut.—Madras (73), Burma (16), Bombay (10) (99 per cent. of whole).

Sesame.—Burma (26·2), United Provinces (25·9), Madras (17·8), Central Provinces and Berar (13), Bengal (4·8), Behar and Orissa (4·6), Bombay (3·7), Punjab (2·5).

Rape and Mustard.—United Provinces (41·7), Bengal (18·5), Punjab (14·8), Behar and Orissa (13), Assam (4·9), Sind (4), North-West Frontier Province (1·6).

Linseed.—Central Provinces and Berar (33), United Provinces (29), Behar and Orissa (25·6), Bengal (5·3), Bombay (5·1), Punjab (1·2).

Cotton (distribution refers to the entire cotton crop).—Bombay (26·7), Central Provinces and Behar (20·3), Madras (10·9), Hyderabad (12·9), Central India (4), Baroda (3·6), Burma (1·6), Punjab (8·2), United Provinces (5), Gwalior (2·1), Sind (1·2).

On the whole, these areas have not undergone any very marked changes of late years. The great drought of 1918-19 caused a sharp decrease in production, and the War also caused a certain amount of dislocation, but a state of equilibrium seems now to have been reached.

The percentage share of the principal seeds in the total value of seed exports can be seen from the following table (*Review of the Trade of India*, 1921-22):

	Pre-War Average.	1919–20.	1920–21.	1921–22.
Castor	6·8	0·9	2·1	5·9
Cotton	7·4	13·9	6·2	5·9
Ground nuts	14·5	16·1	16·9	35·9
Linseed	32·8	39·8	36·5	24·7
Rape	17·0	15·1	31·4	18·2
Sesamum	10·2	8·9	2·8	5·4
Other kinds	11·3	5·3	4·1	4·0

On the whole, the relative values of the exports are much the same as before the War. The most marked exception is the increase in the importance of the ground-nut exports at the expense of the linseed in 1921-22.

It will be realized that the exports of oilseeds do not indicate the total trade, as in a country like India, with a population of 319 millions, the home consumption of seed and oil is enormous, and some products which are very widely grown do not appear among the exports at all. This is markedly the case with such cultivated crops as safflower and niger seed, and with practically all the oilseeds obtained from wild plants and trees, except mowra seed.

The total export of oilseeds for India in 1922 was 726,907 tons, worth about 17 million pounds, and distributed as follows:

	1921–22 (*Tons*).	1913–14 *for Comparison* (*Tons*).
To United Kingdom	219,239	508,765
" Hong Kong	—	10,131
" Ceylon	2,991	4,230
" Egypt	2,828	—
" New South Wales	10,940	3,294
" Straits Settlements	—	2,242
Total to British Empire	238,543	528,662

	1921–22 (*Tons*).	1913–14 *for Comparison* (*Tons*).
To Germany	61,588	200,774
„ Netherlands	27,773	14,632
„ Belgium	97,946	217,872
„ France	204,428	455,253
„ Italy	52,853	71,288
„ Korea	2,991	—
„ United States of America	20,815	20,319
„ Austria-Hungary	—	43,101
Total to foreign countries	488,364	1,023,239

It should be noted that exports during the 1919-23 period to the British Empire show a very considerable decrease compared with 1913, the figures for 1921 and 1920 being 306,194 and 515,551 tons respectively. On the other hand, exports to foreign countries have risen from 302,256 tons in 1920 and 311,287 tons in 1921, to 488,364 tons in 1922, but in most cases this is simply a return to the pre-war state. The countries chiefly responsible for this increase are Germany (whose imports from India have increased yearly since 1919), although they have not reached their pre-war proportion), and in fact, all the countries mentioned in the above table have enormously increased their demand. The exports to U.S.A. in 1921 were only 3,999 tons, and Korea appears for the first time in 1922 as an importer of a considerable proportion of Indian oilseeds.

It is interesting to compare the percentage shares of the principal countries in the total *values* of oilseed exports of India, and the following table* shows pre-war averages compared with modern conditions:

	Pre-War Average.	1919–20.	1920–21.	1921–22.
United Kingdom	23·3	51·3	41·1	24·4
Other parts of British Empire	1·4	2·4	4·5	4·0
France	29·2	25·0	12·5	30·6
Belgium	18·2	10·8	28·0	14·0
Italy	4·6	6·5	6·0	8·2
Germany	14·2	0·2	4·6	8·8
Austria-Hungary	3·3	0·4	0·6	1·8†
Other foreign countries ..	5·8	2·5	2·7	8·2

It is noteworthy, however, that if the participation of the various countries in the *total tonnage* of exports of seeds is considered the proportions are different from those given in the above table. Thus, before the War the United Kingdom absorbed a third of the Indian exports by weight as against a quarter by value; France, a fourth by weight and a third by value; and Germany, an eighth by weight and a seventh by value.

* *Review of the Trade of India in 1921–22.*

† Figures prior to 1921–22 represent Austria-Hungary.

The chief seeds imported to the United Kingdom are linseed, cotton, and castor, which are relatively cheap seeds, while the value of Germany's imports was chiefly due to coconut and mowra seed.

For statistical purposes the ports of India are grouped under five main heads: Bengal, Bombay, Sind, Madras, and Burma. All five are to a greater or less extent interested in the oilseeds trade, but it will be seen from the figures reproduced below that the bulk of the trade is handled in the ports of Western and Southern India:

EXPORTS IN TONS.

	1919–20.	1920–21.	1921–22.	1922–23.
Bengal	153,943	111,153	124,867	167,141
Bombay.. ..	376,374	231,872	249,118	477,423
Sind	200,097	179,101	131,342	258,816
Madras	86,355	90,360	217,938	272,592
Burma	1,038	4,995	3,142	1,073

Indian export trade in oils is not of such great importance as that in oilseeds. This is partly due to the fact that the crushing industry in India is still largely conducted by primitive methods; partly to difficulties of transport by sea. The pre-war average was 16,775 tons, and during the War this figure rose to 28,617 tons, but since 1919 exports of oil have dropped, and in 1921-22 were only 7,317 tons of a value of £311,066.

The oilcake trade is of less volume than before the War; 113,000 tons were exported in 1921-22, valued at £710,466, as against a pre-war average of 140,000 tons, valued at £1,063,700.

BURMA

The trade of Burma is included in the official returns for India, but Burma differs from India in so many important respects, and its development is so much more recent, that the special conditions obtaining in the country are most easily dealt with separately. It is, moreover, a fact, frequently overlooked, that no railroad has yet been constructed linking Burma to India and that all communication between the two is by sea.

It is only since 1852 that Rangoon and Lower Burma have been permanently British; in 1862 Upper Burma was annexed, and since that date progress has been practically uninterrupted and very rapid. Burma possesses a very fertile soil and a fairly dependable rainfall, and a large part of the country is eminently suitable for agricultural development. The total area is 261,899 square miles—about three times that of Bengal—but the country is sparsely populated, and consequently labour is expensive.

The population of Burma in 1921 was 13,212,192, compared with India, 318,942,480. At present there is a great scarcity of roads and means of transport generally, so that development of the more remote districts is much retarded.

In every way the natural resources of the country are more favourable for the cultivation of oilseed crops than in India itself. At present the only oilseed crops

that have become of first importance are ground nut and sesame. There is a large demand for edible oils, and these have been imported from India in considerable quantities. With the extension of ground-nut and sesame cultivation, however, the imports of these commodities have decreased. In 1921-22 the total areas under oilseeds were as follows:

Linseed	421 acres.
Sesamum	1,033,674 ,,
Rape and mustard	3,301 ,,
Ground nut	305,789 ,,
Coconut	11,674 ,,
Castor	25 ,,
Other oil seeds	35 ,,
Total	1,354,919 ,,

Sesamum comes second only in importance to rice when considering the total cropped area of Burma, but even so the home demand is not satisfied and imports from India and the Straits Settlements are necessary. Ground-nut cultivation has only assumed important dimensions within the last twenty-five years, but, as will be seen by reference to the Indian area figures, Burma is now ahead of Bombay in the matter of production, and is beginning to export ground nuts. Freight restrictions during the War appear to have had a marked effect on the development of the oil industry, and the oil-crushing mills have become of great importance to the province. In 1917 the mills dealt with some 300,000 tons of sesame, ground nuts, and some cotton seed and although the local demand for oil was not fully satisfied the imports of oil diminished to about a third of what they were formerly, while some locally produced ground-nut oil was exported to the United Kingdom.

There is little doubt that further developments in oilseed cultivation are possible, but these must depend to a large extent on the better opening up of the country and the provision of roads and railways.

Coconuts should do well, particularly in the southern parts, and there is already a small copra industry at Mergui. The total value of oilseed exports in 1913-14 was £275,000, and of oilcake £144,000, but owing to local crushing the oilseed exports since diminished.

Cotton Seed.

The total area under cotton is larger than for any other oilseed, and the output of seed greater, although of late years ground nuts have run cotton seed very close. The total area under cultivation has not altered very appreciably since 1900, and the amount of seed exported is usually between a fifteenth and a twentieth of the estimated total production.

The seed retained is partly used for the production of oil, which is used for edible purposes, but the internal consumption of cotton oil is probably less than of most other native produced oils. In some districts, particularly the Punjab, a great deal of cotton seed is used for feeding milch cows; this is a wasteful procedure, but local prejudice is difficult to combat. It may be noted that,

although Burma's contribution to the cotton-seed crop is only about $1\frac{1}{2}$ per cent. of the whole produced in India and Burma, yet something like half the cotton cake exported (the total amount of which is, however, small) is Burmese.

Indian cotton-seed exports are nearly all to the United Kingdom:

	1922 (*Tons*).
United Kingdom	144,658
Other British Possessions	4,505
Total	149,163

The export trade in cotton oil is small. In 1919-20, 552 tons were exported, nearly all to the United Kingdom, and mainly from Burma, but in 1921 the figure was even less, and there were no imports of Indian cotton oil to the United Kingdom in 1921 or 1922; 2,359 tons of cotton cake, however, were exported in 1922.

Linseed.

Linseed is much more widely distributed in India than ground nut. The Central and United Provinces, with Behar and Orissa, account for about 88 per cent. of the total production, but cultivation is carried on as far north as the Punjab. The linseed crop occupies a peculiar position in India in that the great bulk is exported and the crop is cultivated entirely for seed. There appears to be little demand in the East for drying oils of the type of linseed, whereas manufacturing countries like the U.S.A. require huge quantities. India is now the third most important producing country, although at one time she held the dominant position in the world's trade in linseed.

The total exports of linseed from India in 1922 were 310,109 tons. Exports for 1921 were 106,607 tons, and this figure is the lowest recorded since 1909, and appears to be chiefly due to decreased cultivation in the Central Provinces, Behar, and Hyderabad State. The recovery in 1922 is very marked. The chief destinations of the exports are as follows:

	1922 (*Tons*).	1913 *for Comparison* (*Tons*).
United Kingdom	161,573	134,822
Australia	11,132	—
Belgium	30,656	33,621
France	49,237	109,185
Italy	29,051	23,455
Netherlands	10,341	—
Germany	4,050	44,356
Other countries	14,069	21,691
Total	310,109	367,130

Very little linseed is crushed in India, and the exports of oil are insignificant and of rather inferior quality, amounting in 1920 to over 1,000 tons, in 1921 to

140, and in 1922 to 132 tons. Oil is supplied to the local varnish industry, but native producers do not, as a rule, boil their oil at all successfully, and very few mills satisfy the Government specification in this respect. In 1922, 10,316 tons of cake were exported, nearly all to the United Kingdom.

Ground Nut.

The ground-nut crop is practically confined to the provinces of Madras and Bombay, and to Burma, and has only become of first importance to India during the last twenty to twenty-five years. The acreage has increased enormously, as will be seen from the following figures:

Averages of Yearly Acreage.

	1904–09.	1909–14.	1914–19.	1919–22.
Madras	518,200	948,560	1,442,200	1,390,667
Bombay..	112,120	222,840	249,800	203,000
Burma	197,800	166,000	258,800	292,667
Total	828,120	1,337,400	1,950,800	1,886,334

The total acreage for 1922-23 is estimated at 2½ million acres, with an output of 1,157,000 tons. Roughly, about half this crop is usually retained in India, where the oil is consumed and about four-fifths of the cake used for manuring high-priced crops and one-fifth for cattle feeding.

The total exports of ground nuts in 1922 amounted to 263,624 tons, valued at £4,916,974, and of this 9,467 tons went to the British Empire, chiefly to the United Kingdom, 159,196 to France, 26,669 to Italy, 17,639 to Belgium, and 31,015 tons to Germany. These figures show that France has practically regained her pre-war position with regard to imports of Indian seed, while the United Kingdom took in 1922 only about two-thirds of the quantity absorbed in 1920-21; Germany, on the other hand, took more than three times her pre-war average. The exports of ground-nut oil in 1922 only amounted to 240 tons.

There is no doubt that, as a rule, better oil is obtained from undecorticated ground nuts, but owing to the bulk occupied by such seed very little is shipped from India in the shell. Better condition of the decorticated kernels could be achieved if more care were given to the decorticating process. The universal method of decorticating in India used to consist of damping and beating with sticks. Damage was caused to the kernels by the beating and discoloration by the damping, while fermentation was readily induced, with the result that the oil produced was rancid and of high acidity and unsuitable for the production of high-grade refined oil. The use of decorticating machinery is, however, growing, to the great advantage of the quality of the exported seed. The importance of improvement in this direction may be realized by comparison with conditions of African trade in ground nuts. Most of the West African ground-nut exports go to Marseilles, and the freightage question is of comparatively little importance, so that the bulk of the seed is shipped in the shells and realizes a higher price, owing to the fact that the nuts reach the oil mills in good condition and yield oil suitable for refining for edible use.

Rape and Mustard Seed.

Indian trade in these seeds is large, and includes a great number of varieties of *Brassica campestris*. True rape seed is very liable to be confused with mustard, and for trade purposes the two are taken together, but the figures refer mainly to rape. The total area under these crops in 1922 was 6,213,000 acres. Rape is grown in many different parts of India, but chiefly in Upper India. It is a hardy crop, and its cultivation extends to the North-West Frontier Province.

The Indian export trade for 1922 to the largest buyers is summarized below and compared with that of 1913-14:

	1922 (*Tons*).	1913–14 (*Tons*).
United Kingdom	43,484	16,832
Germany	71,799	57,856
Belgium	73,762	77,985
Italy	20,037	10,024
Netherlands	19,018	—
France	28,312	47,104
Other countries, including Japan	3,096	8,363
Total	265,318	218,164

Since the total production of rape seed in 1922 was well over a million tons, it follows that home consumption of this commodity is enormous.

Most of the exported rape comes from the province of Sind, via Karachi, and is chiefly yellow or brown " sarson " seed (Indian colza) or the brown tori (Indian rape).

It will be noticed that Japan appears as an importer of Indian rape seed in 1922, and this is the first time she has entered the Indian market. The annual demands of France for Indian rape seed had very much diminished of late years, but showed a sudden increase in 1922. Exports to the United Kingdom in 1922 were about four times those of the previous years.

A consideration of the figures given above shows that a very large amount of seed is treated in Indian oil mills, and there has always been a certain amount of trade in exported oil. Most of this oil comes from Bengal, and is exported to the British Empire, chiefly to Mauritius and Natal for the Indian coolie population, and in 1922 the total exports of mustard and rape oils amounted to 1,579 tons. Very little rape cake is exported.

Sesame Seed.

Sesame is very largely grown in India for home consumption as in the case of rape. The exports of 1922 were only about a fifteenth of the estimated production. It is, however, particularly difficult to form any accurate estimate of the out-turn of seed, as sesame is largely grown as a catch crop and mixed with other crops.

It may be noted that over a million acres are under sesame in Burma, and the whole Burmese crop is retained for home consumption. In India the total area under sesame has not altered very materially during the last twenty years, but exports are not now on such a large scale as formerly.

The chief destinations of the exports are as follows:

	1922 (*Tons*).	1913–14 (*Tons*).
Italy	17,147	8,674
Germany	—	14,241
Netherlands	4,532	—
Austria-Hungary	10,648	21,633
France	7,694	24,480
Belgium	4,050	29,166
Other countries	7,583	4,229
Total	51,654	102,423

China is by far the largest exporter of sesame seed, and it is from China that the United Kingdom in the past derived the bulk of its supply of the seed, but the demand in the United Kingdom for sesame seed has never been large, except during the War, in 1916-17, the United Kingdom imported 21,297 tons from India.

Of late years the requirements of the United Kingdom have only been in the neighbourhood of some 5,000 tons, and in 1922 the imports dropped to 76 tons.

The exports of sesame oil are small, but have remained fairly constant for a number of years; in 1922 the exports amounted to 414 tons. Sesame cake is exported in fair quantities; thus, in 1922, 17,981 tons (including a certain amount of rape-seed cake) were exported from India to Ceylon.

Copra.

Indian trade in copra has declined very appreciably. Before the War exports were in the neighbourhood of 30,000 tons a year, but dropped from 1914 onwards, till in 1918 they were only 639 tons; since then they have recovered somewhat, and in 1921 were 3,099 tons, and in 1922 about 15,000 tons, showing that conditions are gradually returning to normal. Before the War the bulk of Indian copra exports went to Germany. In 1913 Germany took 28,000 tons (including re-exports from Belgium) out of a total Indian export of 37,000 tons, so that with the closing of the German market a rearrangement of trade was necessary. In spite of the shrinkage of the total Indian copra exports, imports to the United Kingdom from India went up enormously, and in 1919-20 reached a value of £383,000, compared to a pre-war average of £25,500. In 1920-21 and in 1921-22 the value had fallen to the pre-war level. The German trade in Indian copra has not, however, so far regained its pre-war condition.

Exports of copra have been practically confined to the Malabar coast, and Malabar copra has for years commanded a higher price than any other copra on the world's market. This difference in price has been one of the difficulties in the way of diverting the Indian copra trade to this country, for English and French crushers claim to be able to produce as good oil from inferior and cheaper

*grades as the Germans did from the Malabar copra, and if marked differences in price continue it is hardly likely that English mills will make use of the Indian article. The great drop in exports in 1918-19 appears to be accounted for chiefly by the lack of freightage, for when freight is short copra is too bulky a cargo to be popular.**

These export figures give little idea of the actual production in India, and it is, unfortunately, not possible to give areas under production. The area in the Madras Presidency has been estimated at 800,000 acres, with a total annual yield of at least 800 million nuts. The produce of Bombay, Bengal, and Coromandel is all consumed locally. An estimate of Indian coconut consumption has been put at nearly 400 million nuts a year.

Exports of coconut oil in the pre-war period averaged 7,238 tons a year, and increased considerably during the War; in 1919-20 they amounted to 19,800 tons, but fell in 1922 to only 4,959 tons. Most of the export was from Madras, and the bulk came to the United Kingdom, with the United States of America as the second largest importer.

It may be noted that there is a good deal of coastwise trade in coconut oil, but there is little doubt that much less coconut oil is being produced in India than was the case in 1918, although it is difficult to gauge the internal demand for the oil, which is certainly large.

Exports of coconut cake are not large, and do not reach pre-war figures. In 1922, 2,026 tons were exported, all to the United Kingdom. Most of the cake is used in India.

CASTOR SEED.

India is the chief source of supply of castor seed, but figures denoting areas under cultivation are not available. The exports of the seed are large, and it is known to be used locally in India to a considerable extent.

The maximum export since 1909 was in 1913 with 130,720 tons. Exports were, on the whole, well maintained during the War, but in 1919 they had fallen to 10,475 tons. Since then, however, they have steadily increased, reaching in 1922 the figure of 85,475 tons. Formerly about half the total Indian exports of castor seed went to the British Empire, almost entirely to the United Kingdom, but latterly a change has come with the continued demand from the U.S.A., coupled with a decreased demand from the United Kingdom and France.

	1922 (*Tons*).	1913 (*Tons*).
United Kingdom	18,627	54,273
U.S.A.	32,324	20,356
France	15,949	20,492
Belgium	8,266	14,889
Italy	7,585	10,112
Other countries	2,724	10,601
Total	85,475	130,723

* *Handbook of Commercial Information for India*, Cotton, p. 184.

The exports are chiefly from the port of Bombay. As is explained in Part I. (p. 74) under "Castor Seed" the European, in fact the world, demand is likely to continue (in spite of the fact that the special war demands no longer exist) on account of the increased use of the oil for engine lubrication. Formerly Indian trade in castor oil was on a much larger scale than at present. In 1879-80, 11,045 tons of oil were exported and 11,880 tons of seed, but the primitive methods of oil expression were not able to compete with the European processes, and gradually the seed exports increased at the expense of the oil. In 1922, 2,031 tons of oil were exported, of which about two-thirds went to the United Kingdom.

Castor cake is in considerable demand in India for manuring purposes, and quantities are exported to Ceylon for use in the tea plantations. The total export of cake in 1922 was 1,436 tons, all to Ceylon.

Mowra Seed.

As mowra seed is gathered from forest trees which continue to bear for a very large number of years, it is not so much the total production that varies from year to year as the proportion of seed collected, and this varies with the demand. Before the War exports of mowra were in the neighbourhood of 30,000 tons a year, most of which went to Germany, but latterly the exports of this seed have been much less, and have not approached the pre-war level. In 1921, 2,447 tons were exported, chiefly to Belgium and France, and in 1922, 19,186 tons.

Poppy Seed.

As has been explained in Part I. (p. 50), cultivation of the poppy seed has much diminished, and the exports are not now very considerable, the 4,017 tons exported in 1922 going nearly entirely to France, and only a very small quantity reaching the United Kingdom.

Niger Seed.

Although niger seed is grown in India and crushed locally for home consumption, it is very difficult to obtain any idea of the extent of the industry. The seed yields on crushing rather less oil than rape, and the value of the oil is slightly less per ton, and distinctly less than sesame. For this reason and the fact that the same conditions of cultivation suit niger and sesame, it is not likely that niger cultivation will extend. At one time the oil was sold at a slightly higher price than rape, and exports of the seed were then higher. The following table compares the prices of niger, sesame, and rape seed:

	1910–11.	1911–12.	1912–13.	1913–14.	1914–15.	1922.
	£ s.	£ s.	£ s.	£ s.	£ s.	£ s.
Niger seed, per ton ..	9 16	10 3	10 3	10 9	9 12	17 15
Sesame	13 3	14 5	15 12	16 0	15 4	23 5 (Chinese)
Rape	9 8	10 0	11 0	11 9	11 2	21 0
Exports of niger seed in tons		10,105	5,684	4,107	2,330	354

In view of the fact that the price of niger seed is consistently lower than that of rape seed the decline in cultivation and exports is likely to continue.

Formerly most of the niger seed from India went to the United Kingdom, France, and Germany, but now almost the whole crop is consumed in India.

General Remarks on Conditions in India.

One of the outstanding facts that emerges from a consideration of the foregoing remarks is that whereas previous to the War India had a definite export trade in oil, which during the War period augmented considerably, this has since diminished, on the whole, to a lesser bulk than in 1913. The increase of production of oil during the War period is easy to understand in view of the increasing difficulties in securing freightage and the bulky nature of oilseeds.

Towards the end of the War period oil-mill capacity in the United Kingdom and various other European countries very greatly increased, chiefly in order to cope with the rapidly expanding margarine industry, and now the crushing capacity of the United Kingdom is greater than the demand upon it—in fact, crushers are, at the moment, only working about half capacity. Probably this is also the case in France, and it is hardly likely that the demand for imported oil will, under these conditions, again reach its previous large dimensions, although if the price of the imported oils was sufficiently low and their quality good, this might be so.

In view of these conditions and the future prosperity of the Indian oil industry, the local outlet in India must increase. There is little doubt that the demand in that country is already on the increase, and particularly is this so in the case of edible oils. Of late years the price of ghee* has increased so that it is, to some extent, at least, outside the purchasing powers of the poorer population; and to supply this deficiency the demand for the cheaper vegetable oils has increased, while the partial substitution of the army ghee ration by oil has still further influenced this demand for vegetable oils.

The demand in India for technical oils, on the other hand, has not increased, except that linseed oil has practically ceased to be imported, and castor oil is being increasingly used for lubrication purposes.

It is exceedingly difficult to form any adequate idea of the size of Indian trade in oils. For instance, large quantities of mowra fat are used for candle-making (mowra fat yields 30 to 35 per cent. of stearic acid and the resulting oleine for soap); huge quantities of safflower oil are known to be produced, probably in the neighbourhood of 15,000 to 20,000 tons a year, but figures of production are difficult if not impossible to obtain. Malabar tallow (from *Vateria indica*), kokum butter (from *Garcinia indica*), karang oil (from *Pongamia glabra*), and many other oils are locally produced and used in India, but to what extent can hardly be surmised.

If the export trade in Indian oils is to be increased, one very necessary condition is an improvement in the quality of the oil produced, for the oil has to compete with that obtained in Europe by modern crushing and extracting machinery. Refining as understood in Europe is not much practised in India, for in that country a very low standard is sufficient in oils used for edible purposes.

* Clarified butter.

A suggestion has been made that all oils for export purposes should be graded at Government test houses, but no scheme is yet in operation, though it would certainly be of some assistance to foreign buyers. It must also be remembered that most European countries impose substantial import duties on a manufactured product such as oil.

The corollary of a successful oil industry is a trade in the resulting oilcakes and meals. In a country like India, agricultural conditions are very different from those found in Europe. For instance, there is practically no industry corresponding to the fat stock industry of Europe, and there is nothing like the demand in India for concentrated food-stuffs that are so much used in Europe. In India a great deal of oilcake is used for manuring the richer crops, and with a view to preventing the exhaustion of the soil an increased use of cake for this purpose is to be encouraged. Cotton seed is fed very largely to cattle in India, and this is a very wasteful procedure, both as regards loss of oil and cotton, and the feeding of a large bulk of undigestible material to the cow.

It is certain that there is room for an increased use of oilcakes in India, both as feeding stuffs and manure, and an increased oil industry will necessarily mean an increase of oilcake. Undoubtedly, it would be beneficial to the country to use this surplus of cake at home, but questions of great complexity are involved, one of the chief being ability and willingness of native cultivators to pay a price equal to what the manufacturers can get for the cake in foreign countries, less freightage charges. The demand in Europe for oilcakes is steady, and there is not likely to be any difficulty in disposal of large quantities there.

Lac-Resin (Shellac).

Although the lac insect is widely distributed in India, the great bulk of the lac produced is obtained from one area which comprises Chota Nagpur, Orissa, the north-eastern half of the Central Provinces, and extends into part of Bengal and also into the Mirzapur district of the United Provinces. The following figures show the lac out-turns in different districts:

	Per Cent.	*Average Total Crop (Maunds*).*
Main area	86·6	1,003,500
Sind	2·2	26,000
The Punjab	2·9	33,000
Assam	3·0	65,000
Burma, etc.	5·3	62,000†
Total	100·0	1,189,500, or about 868,340 cwts.

It would appear that the annual production of stick-lac *in India alone* must amount to some 800,000 hundredweights, the majority of which is converted into shellac and other forms, and exported.

* 1 maund=82⁶⁄₇ lbs., or 0·73 cwt. approximately.

† Including 7,000 maunds from French Indo-China, 16,000 maunds from Siam, 9,000 maunds from Straits Settlements.

The chief centre of lac manufacture in India is Mirzapur, but owing to better transport facilities Calcutta has, in recent years, assumed greater importance; during the period 1901-05 some 37 per cent. of the manufacture was in Mirzapur, but this had fallen to 25 per cent. during the period 1914-18. Calcutta is the great market and export centre of India's lac trade, some 97 per cent. of the total exports being shipped from that port; the quantities from Karachi, Bombay, and Madras together only amounting to 6,200 hundredweights in 1913-14. Shellac and the other forms of lac are shipped from Calcutta either in cases or double gunny bags holding 2 maunds (1½ hundredweights, approximately).

It is not possible to estimate exactly how much of this total production is locally absorbed, but the great importance of the lac industry is well illustrated by the exports of shellac, etc., shown below.

The following table shows exports before the War and in recent years, and indicates, at the same time, the relative importance of the different forms of lac-resin and the chief destinations of exports:*

	1912 (*Cwts.*).	1913 (*Cwts.*).	1921 (*Cwts.*).	1922 (*Cwts.*).
All kinds .. Total	419,898	354,536	394,268	428,018
All kinds .. Value (£) ..	1,314,760	1,351,109	4,683,470	5,973,312
Button lac to:				
United Kingdom	22,811	17,152	5,301	10,209
Germany	8,655	3,121	—	—
United States of America	1,283	263	1,200	3,439
Other countries	6,921	5,016	1,364	3,260
Total	39,670	25,552	7,865	16,908
Shellac to:				
United Kingdom	56,328	66,365	64,710	66,991
Germany	65,092	30,855	9,766	18,687
France	24,684	14,130	7,037	9,890
Italy	—	—	2,327	4,122
Netherlands	8,250	2,771	—	—
Austria-Hungary	11,631	5,369	—	—
United States of America	150,434	149,546	244,836	212,275
Japan..	—	—	11,350	16,228
Canada	—	—	3,089	895
Australia and New Zealand ..	—	—	2,232	3,576
Other countries	16,324	9,667	6,887	9,121
Total	332,743	278,703	352,234	341,785
Stick lac	11,468	7,138	844	2,528
Seed lac	14,001	18,939	1,441	3,401
Other kinds	22,016	24,204	31,884	63,396

Practically the whole of the export of shellac is the produce of Bengal; in 1922 341,766 hundredweights were from this source.

The average annual exports of all kinds of lac from India, in pre-war years, have been estimated as 400,000 to 425,000 hundredweights, valued at about

* Figures are taken from the *Accounts of Sea-Borne Trade and Navigation of British India.*

£1,350,000. Lac exports from other sources were comparatively small. Indo-China exported annually about 11,100 hundredweights of stick-lac during 1910-13, and Siam annually about 12,750 hundredweights of stick-lac during 1911-12 to 1913-14.*

Burma as a source of lac is obviously of secondary importance. Most of the Burma lac is exported to India as stick-lac and worked up in India, and part of this Burma export lac is derived from sources outside Burma and imported to Burma across the frontier.

The exports of lac from Burma have been very variable in recent years, as the following figures show:

EXPORTS OF LAC FROM BURMA TO CALCUTTA.

1911-12	1,777 cwts.
1912-13	9,454 "
1919-20	45,036 "

With the exception of 1903-04, when the export was 30,979 hundredweights, the figure for 1919-20 is the largest since 1866.

Imports of lac-resin to India are small and vary considerably from year to year. They are composed almost entirely of stick and seed lac. The imports in recent years are as follows:

TOTAL IMPORTS OF LAC TO INDIA.

1920	28,260 cwts.
1921	6,128 "
1922	41,419 "

A consideration of the destinations of India's exports in pre-war years and in recent years affords some interesting comparisons. Thus the total exports of lac of all kinds are now of the same order of magnitude as before the War, but button lac and stick-lac and seed lac have decreased in importance, while shellac and "other kinds" (garnet lac, dust, etc.) have increased.

The exports to the United Kingdom are now about the same as they were before the War, but those to the United States have increased from about 150,000 to well over 200,000 hundredweights—in fact, to nearly 245,000 hundredweights in 1921.

Germany is again taking Indian lac, but in much smaller quantities; exports to France also are much smaller, while Japan appears as a fairly considerable buyer.

The lac industry in India has been described already at some length, and it does not appear necessary to attempt to discuss here the various problems connected with this important industry; these problems have received considerable attention in the past from the Indian Forest Department, and it is evident that the industry will benefit greatly from the continued and increased research and organization which has been suggested.

* *Report on Lac, etc., Indian Trade Enquiry Impl. Inst.*

As chemists, the authors might venture to suggest that development and research is particularly needed in the manufacture of shellac from the crude lac, and that the possibility of the production of an artificial substitute, which would seriously compete with shellac, must not be overlooked. With regard to this latter point there is no desire to cause alarm; time has shown that the alarm caused by the synthetic production of rubber, some years ago, was really unfounded and that the natural product has been able to hold its own absolutely, but the enormous increase in scientific efforts in recent years tends to show that the possibility of "synthetic shellac" cannot be neglected.

ROSIN AND TURPENTINE.

Pinus sp., Resin and Turpentine.

The possibility of utilizing the large areas of pine—chiefly the "chir" pine (*Pinus longifolia*)—in India as sources of rosin and turpentine is a most important question which has received a great deal of attention for some years past. Up to 1912 production of rosin and turpentine was on a small but gradually increasing scale; since that date production has steadily increased, and appears to have a promising future. It has been estimated that India and Burma should be able ultimately to furnish yearly over 430,000 hundredweights of rosin and 120,000 hundredweights of turpentine.* The production of rosin and turpentine is carried on in the Government factories at Jallo in the Punjab, Bhowali in the United Provinces, and in the more recently erected factory at Bareilly.

The growth of this industry and its effect on the importation of rosin and turpentine in India is shown in the following figures:*

Year.			*Production.*	*Imports.*
1907–08	Rosin	Cwts.	4,870	76,525
	Turpentine	Gallons	16,036	333,530
1912–13	Rosin	Cwts.	20,544	61,017
	Turpentine	Gallons	60,249	270,127
1919–20	Rosin	Cwts.	50,077	13,906
	Turpentine	Gallons	152,422	111,917

The Punjab factory at Jallo has a maximum capacity of about 19,000 hundredweights of rosin and 70,000 gallons of turpentine.† The factory at Bareilly, where operations were started in 1920, was designed to produce 59,000 hundredweights of rosin and 240,000 gallons of turpentine, allowances being made for considerable extension of output as required; it has been estimated that when this factory produces the full output (240,000 gallons) of turpentine, the production of turpentine in India will satisfy local requirements.

The development of the Indian rosin and turpentine industry depends very largely, if not entirely, on transport facilities in the pine forests which are at

* *Handbook Commercial Information for India*, 1919, p. 320.

† *Imperial Institute Indian Trade Enquiry, Report on Turpentine, etc.*, p. 31.

present inadequate. Until recently development was entirely in departmental hands, but the co-operation of private capital has now been secured. Exploitation by private enterprises alone is considered undesirable, owing to the difficulty of controlling the working of forests by private concerns, and the necessity of Government control of forests in the interests of the nation.

The crude oleo-resin worked in India differs somewhat in character from American and French oleo-resin, and a considerable amount of work has been done in India by the Forest Research Institute at Dehra Dun, and at the Imperial Institute in London, to devise efficient methods of manufacture of rosin and turpentine.* Much work has also been done on the composition† and commercial utilization of the rosin and turpentine produced, the results of which it is unnecessary to describe in detail. Broadly, Indian rosin, when properly prepared, compares favourably with commercial French or American rosin, while the turpentine, though differing in character from French or American turpentine, obviously meets the requirements of manufacturers in India, and would certainly be saleable in Europe.

A ready and accessible market for rosin is provided by the sugar industry in Java, while inquiry for both rosin and turpentine of Indian manufacture is increasing in the United Kingdom.

To summarize the position briefly it is obvious that the demand in India for rosin and turpentine will eventually be met by home production, and that an exportable surplus will be available.

Boswellia serrata.

In considering the production of turpentine and rosin in India, reference must be made to *Boswellia serrata*, a tree of the Natural Order Burseraceæ, which includes other trees of some economic importance, such as those yielding myrrh and frankincense.

The oleo-gum-resin of this tree has long been used in India in incense. A considerable amount of work has been done on the utilization of this tree as a source of resin and turpentine at the Indian Forest Research Institute, Dehra Dun, and also in England at the Imperial Institute.‡ It has been established beyond doubt that the turpentine and rosin produced would be readily saleable at prices close to those ruling for the ordinary American or French products.

Considerable areas of the tree exist in the dry zones of India—for instance, in the Central Provinces and in the north, east, and west Khandesh Divisions of the Bombay Presidency; and it is estimated that some 6 million trees might be tapped in the Shirpur Range alone in North Khandesh.

Tapping experiments have been conducted on a fairly large scale with good results, and the trees appear to stand tapping well without being damaged or killed.

* Troup, *Work of Forest Dept. in India*, 1917.

† *E.g.*, *Proc. Chem. Soc.*, 1911, **27**, 247, H. H. Robinson; *Journ. Chem. Soc.*, 1920, **117**, 570, Simonsen; *Impl. Inst. Ind. Trade Enquiry Report on Turpentine*, etc.

‡ *Indian Forest Records*, 1918, **6**, 303; *Bull. Impl. Inst.*, 1919, **17**, 159.

The chief difficulty involved appears to be that of separating the volatile oil (turpentine), resin, and gum. The turpentine may be easily distilled from the crude material, but a residue of resin and gum is left, the separation of which is not an easy matter on a technical scale. Resin may be separated by treatment with a solvent in which the resin is soluble, and the gum insoluble, and this method has been tried and found to produce resin of good quality. The present authors feel rather doubtful if the use of solvent for the recovery of a relatively cheap material—such as this resin is—would be possible commercially, especially in India, where solvents would be expensive. All the samples of the gum seen by the authors are undoubtedly of poor quality and of little or no value for any technical purposes.

So far *Boswellia serrata* does not appear to have been exploited on an appreciable commercial scale, but it undoubtedly offers possibilities of increasing India's supplies of turpentine and rosin.

CEYLON

Ceylon is an island with an area of 25,481 square miles, and a population of about 4½ millions; it is situated between latitudes 5 and 10 degrees N., and is therefore entirely in the tropical zone. It occupies a central position in Asia, is only 22 miles from India, and is therefore admirably situated from a trade point of view. Ceylon is essentially an agricultural country, the three staple crops being tea, rubber, and the coconut-palm. The north and north-central parts of the island are occupied by one great plain, while towards the south is the circular mountainous district.

The total area under coconut is computed for 1922 as about 820,000 acres, which shows a slight decrease on the pre-war figures, but is about a third of the whole cultivated area of the island. The west and south-west districts are most prolific in coconut, but the palm is planted along large tracts of coast in most of the provinces.

The coconut along the coast of the west and southern provinces is mainly used for supplying toddy to the arak distilleries, and not for the production of copra. Coconut products take the third most important place in Ceylon exports, and are the only oleaginous products that have so far taken a leading position in the trade of the island. Ceylon became a Crown Colony in 1802, and it is since that date that the industry has grown, the beginning of the plantations dating from about 1840.

Exports of coconut products from Ceylon are as follows:

	1909–13 (*Average, Tons*).	1921 (*Tons*).	1922 (*Tons*).
Fresh coconuts	16,000	23,739	47,000
Desiccated coconut ..	14,000	43,526	22,317
Copra	40,960	68,372	84,329
Coconut oil	26,700	24,236	27,731
Coconut cake	—	—	5,093

A consideration of these figures indicates the enormous growth that has taken place since the pre-war period in everything except the coconut-oil trade.

Desiccated Coconuts.

The demand for this product has shown a very marked increase of late years, particularly in the United Kingdom and the United States of America. The demand in the United States of America has only assumed its present large dimensions since the passing of the " dry " laws, and this fact may be of significance. Ceylon is the only country growing coconuts that manufactures desiccated coconut on a large scale,* and under the boom, mills have been erected in Ceylon especially for its preparation. Some of these are capable of dealing with 50,000 nuts a day (1,000 nuts produce 330 to 375 pounds of desiccated coconut), and the product is packed in 130 pound boxes lined with tea lead and packing paper. In 1921 there was a fall in price for desiccated coconut, and this caused some of the mills to close. However, an improvement took place later, and this may lead to their re-opening.

Ceylon desiccated coconut is exported in about equal quantities to the United Kingdom and the United States of America. In 1922, 14,527 tons went to the former, and 13,687 tons to the latter; Germany took 4,143 tons in the same year, Australia 1,766, and Spain 500, the total exports being 38,410 tons, valued at 20,159,183 rupees. The product is also manufactured in Europe and America from imported fresh coconuts, and the imports of coconuts are chiefly regulated by the demand for desiccated coconut.

Coconuts.

Ceylon does a large trade in the fresh nuts, and the increase in the exports for 1921 corresponds with the increase in demand for desiccated coconut, as the nuts are mainly used by many of the importing countries for the manufacture of the desiccated product. The United Kingdom takes the bulk of the exports, and the quantity in 1922 amounted to about 11,500 tons, the total quantity exported being 22,300 tons, value 1,825,226 rupees. Egypt came next with 7,200 tons.

Copra.

The Ceylon copra industry is on a very large scale, the total exports for 1922 being 84,329 tons. The copra is largely prepared by sun-drying, but when artificial drying has to be resorted to it usually takes the form of kiln-drying. The exports in 1922 very nearly touched the record figure of 1919 of 87,976 tons. The largest importer was Italy, with the United Kingdom and Denmark next. The following shows the destinations of exports in 1922 compared with those of 1913.

* See p. 201.

EXPORTS OF COPRA (TONS).

Principal Exports.	1913.	1922.
United Kingdom	750	12,657
Other British Possessions	81	125
Denmark	1,283	12,942
Germany	40,749	8,023
Austria	1,502	—
Belgium	200	—
Norway	—	7,999
Italy	—	23,824
Holland	—	9,212
United States of America	—	2,999
Total exports to all countries	55,863	84,329

The total value of the 1922 exports was 28,804,064 rupees.

The exports to the United Kingdom are encouraging, as before the War they were negligible. However, the total imports of copra to the United Kingdom from foreign countries were in 1922, 12,684 tons, compared to 6,154 tons in 1913, so that it appears that there is still room for more Ceylon copra in this country.

In spite of the attention given to the coconut industry there is said to be much room for improvement, particularly as regards manuring and clean weeding of the trees. It has been definitely established that young coconut trees to which such attention has been given come into bearing earlier than neglected trees.

On the whole, the plantations in Ceylon do not suffer badly from disease and pests. In spite of the limited area available there are still considerable tracts of uncultivated country suitable for the coconut. In the past the trees were mainly confined to the coast, but gradually plantations have extended inland. The cost of opening up new land for coconut is estimated at 400 to 600 rupees an acre, and ten years is the average waiting period before the trees begin to yield.

COCONUT OIL.

The oil manufactured in Ceylon is usually of fairly good quality, and contains in Ceylon on the average 1½ to 2 per cent. of free fatty acids. With a view to the production and export of "white oil" experiments are in hand, and a higher quality of oil may well be looked for in the future. The bulk of the oil is shipped to the United Kingdom, which usually imports about 15,000 tons of Ceylon coconut oil a year. In 1922 Germany took 5,264 tons, and Egypt and Norway smaller quantities.

COCONUT CAKE.

Very little of this finds its way to other countries, and the bulk is used locally. The total exports of coconut poonac were only a little over 5,000 tons in 1922, and most of this went to Belgium.

OTHER OILSEEDS.

In considering possibilities of future development in coconut-planting in Ceylon and other parts of the tropics, the claims of the West African oil palm

should be noted. This palm has long been grown in gardens, and recently experimental cultivation has been carried out at the Anuradhapura Station. The results have been fairly satisfactory, and some demand for seed from cultivators has been experienced. In localities unsuited to the requirements of the coconut the introduction of this palm would be beneficial.

Another oilseed crop which has been engaging the attention of the authorities is castor seed. Castor cake is a manure of well-recognized value in Ceylon; the demand for the cake is steady, and large quantities are at present imported from India. In order to make Ceylon independent of imported manures, and at the same time produce at home the valuable oil, the cultivation of castor as a mixed crop is being encouraged, and the Government Railway has erected a small extraction plant and proposes to offer good prices for seed.

Other oilcakes are imported from India in considerable quantities, chiefly for use as manure on tea and other plantations.

The imports for 1922 were as follows:

Sesame cake	18,428 tons.
Ground-nut cake	15,025 „
Castor cake	1,658 „
Rape cake	149 „

BRITISH MALAYA

Under the above are included: (1) The Straits Settlements, comprising Singapore, Malacca, Penang, together with Province Wellesley, the Dindings, and the Cocos and Keeling Islands; (2) the Federated Malay States, comprising Pahang, Selangor, Negri Sembilan, Perak; (3) the Unfederated Malay States, including Kelantan, Trengganu, Kedah, Johore, Perlis.

The most important of these, as far as trade is concerned, is the Straits Settlements, in which the port of Singapore is situated and through which most of the exportable produce of the Federated and Unfederated States passes. The population of the Straits Settlements was returned in 1921 as 883,769, and the population of the Federated and Unfederated Malay States rather over a million each respectively. All the provinces are mainly agricultural, and from the oilseed point of view the coconut is far the most important crop. Export figures are almost entirely concerned with the Straits Settlements, but the copra exported from them comes from various parts of British Malaya.

The Federated States probably includes far the largest number of coconut plantations, and the total area under coconut in these States in 1922 was estimated at 193,256 acres, distributed as follows:

Perak	89,662
Selangor	78,680
Negri Sembilan	10,468
Pahang	14,446
Total	193,256

A large proportion of this total area is composed of small plantations, the area of plantations of over 100 acres amounting to only 95,000 acres. The total exports of copra from these States in 1922 was 43,333 tons, valued at £1,020,316, and practically all of this, except for some 4,000 tons, was sent through the Straits Settlements.

Turning to the Unfederated States, Johore probably produces the most copra, but figures of production are not available. Exports of copra for 1922 were as follows:

Johore	24,670 tons.
Kelantan	7,141 „
Trengganu	1,721 „

No figures are available for Perlis and Kedah. The Straits Settlements themselves grow copra, particularly in Penang, Province Wellesley, and the Dindings, but the exports of these provinces are not given separately. An idea of their volume may, however, be gathered from a consideration of the total exports from the Straits Settlements, the contributions to these from the Federated and Unfederated States, and the imports from surrounding countries.

The bulk of trade in copra passing through the two main ports of Singapore and Penang (chiefly the former) is enormously increased by the fact that a large quantity of copra is received for re-export from Sumatra and other Dutch possessions, Borneo, and Siam. The following table of the chief copra imports to the Straits Settlements for 1922 will emphasize this point:

Borneo	20,215 tons.
Sumatra	20,131 „
Other Dutch possessions	15,291 „
Philippines	2,087 „
Siam, etc...	3,629 „
Other sources	4,636 „
Total	65,989 „

The total exports for 1922 were 170,191 tons, valued at £3,526,182. Taking from these the imports given above, and also those from the Federated and Unfederated States, it appears that the exports derived from the Straits Settlements alone were in the neighbourhood of 25,000 tons.

The exports from British Malaya go to a large number of different countries, chief among them being in order of importance Germany, the Netherlands, France, the United Kingdom, and Spain.

The importance of copra in the trade of British Malaya is only inferior to that of rubber and of tin.

The trade in coconuts is not very large, the value of the export trade in 1922 being £38,826. This shows a decrease, for in 1920 the exports were valued at £53,319. The local trade is on a large scale, as the nuts are largely used by the natives for food. Coconut oil is manufactured in several factories in Singapore, and the exports in 1922 were 6,252 tons, valued at £238,430.

Owing to the recently increased demand in the United States of America and in Europe for desiccated coconut, the possibilities of establishing the industry in Malaya have been considered, and as a result a factory for the preparation of this product has been successfully opened in Province Wellesley, but so far exports are not considerable.

The great importance of British Malaya in the trade of the East is indicated by the following export and import figures, which represent very largely the trade of the port of Singapore:

British Malaya: Imports and Exports.

		1921.		1922.	
		Imports.	*Exports.*	*Imports.*	*Exports.*
Oilseeds:					
Ground nuts	Tons	4,900	700	5,227	1,031
	£	114,900	15,800	112,006	22,517
Illipé nuts	Tons	227	450	237	1,793
	£	2,757	4,700	5,518	30,130
Siak beans	Tons	747	2	662	—
	£	6,608	47	6,655	—
Copra	Tons	—	—	65,916	170,191
	£	—	—	1,263,945	3,526,182
Sesame seed	Tons	—	—	1,738	180
Oilcakes:					
All kinds	Tons	2,669	3,623	1,421	3,408
	£	22,600	27,320	12,210	14,360
Oils:					
Castor oil	Cases	1,227	225	1,605	146
	£	3,468	476	4,432	370
Coconut oil	Tons	291	8,174	2	6,333
	£	11,620	359,200	80	239,200
Linseed oil	Tons	3,302	205	4,500	561
	£	18,140	2,022	19,700	2,712
Soya-bean oil	Tons	7,527	830	6,611	734
	£	361,800	38,990	315,900	35,820
Wood oil	Tons	137	37	212	—
	£	7,000	1,296	10,870	—
Sesame oil	Tons	—	—	—	—
	£	2,618	22,360	5,762	1,010

It will be noticed on consideration of these figures that, in several cases, imports are bigger than exports, and it is obvious that a very large proportion of the exports are re-exports of produce imported from surrounding countries. Singapore is the most important port between India, Hong Kong, and Australia, and a great deal of trade passes through it. The destinations of the exports are very varied; for instance, surrounding islands are supplied with such requisites as linseed and soya oils which they do not

not themselves produce, while Eastern produce such as illipé nuts, oilcake, coconut products, are sent to Europe and the U.S.A.

It may be noted that the term "illipé" which appears in the official returns may refer to a large number of seeds (see p. 94), but in the present case would doubtless denote the true Borneo tallow nuts. The siak beans are almost certainly the seeds of species of *Palaquium*, yielding a hard fat, and have been imported from British North Borneo in the past* for local consumption. The imports in the years 1921-22 are recorded as wholly from Sumatra.

The African oil palm is a tree which is likely to become of increasing importance in Malaya. Its cultivation has reached a high state of efficiency in Sumatra, and the climate and soil of Malaya are eminently suitable in many districts. Applications for large areas of land for its cultivation have been made, and it is already growing satisfactorily in several places, though the productive stage has not yet been reached, and the question of factories for dealing with the products is at present unsolved.

The castor-oil plant is also suitable for cultivation in Malay, particularly as a catch crop in rubber clearings, while ground nuts and sesame are receiving attention from the authorities.

The following are statistics† relating to trade in copal, dammar, and turpentine in British Malaya:

		1921.		1922.	
		Imports.	*Exports.*	*Imports.*	*Exports.*
Dammar	Tons	2,545	5,437	3,544	7,251
	£	45,147	104,000	77,200	192,500
Copal	Tons	1,152	1,586	1,247	3,299
	£	42,600	63,600	48,850	132,000
Benzoin	Tons	1,258	2,032	1,411	1,440
Resin	"	10	1·7	41	4
Stick lac	"	—	—	1,615	1,517
Gamboge	"	2·5	2	7	9·5
Dragon's blood	"	26	32·8	33·4	30·3
Turpentine	Gallons	6,878	673	50,275	38,216

The trade of British Malaya in resinous products is, therefore, considerable—in fact, Singapore occupies an important position in the Eastern trade in dammar, copal, etc. The exports of dammar are considerably in excess of imports, and fairly considerable amounts of dammar are produced in British Malaya, almost entirely in Negri Sembilan; the total production in the two years under consideration was 532 and 1,396 tons respectively.

According to the official statistics the principal sources of the imports of dammar were as follows:

* *Bulletin No.* 1, *British North Borneo Forests Dept.*, 1916.

† *Returns of Imports and Exports of British Malaya*, 1922. Values converted from pikuls: 1 pikul = 133 pounds. Quantities converted from dollars: \$1 = 2s. 4d. For rapid conversion: dollars × 0·1166 = £. Values are approximate only.

DAMMAR IMPORTS (TONS).

Principal Sources.	1921.	1922.
From British North Borneo	792	833
" Sarawak	392	411
" Dutch Borneo	429	813
" other Dutch East Indies	613	950
" Siam and dependencies	307	518
Total imports	2,545	3,544

The largest exports of dammar from Malaya in 1921 and 1922 are those to India and the United States; fair quantities go to the United Kingdom and to the Continent and Japan. The principal destinations were as follows in 1921 and 1922:

DAMMAR EXPORTS (TONS).

Principal Destination.	1921.	1922.
To British India	3,625	3,140
" United States of America	793	2,445
" United Kingdom	304	513
Total exports	5,437	7,251

The imports of copal were principally derived from the Dutch East Indies, but the following were imports from British Possessions: from Sarawak 258 and 287 tons, and from British North Borneo 34 and 127 tons, in 1921 and 1922 respectively.

The largest exports in 1921 and 1922 were those to the United States of America and the United Kingdom; the remainder goes chiefly to the Continent of Europe, but Japan and Australia have also taken fair quantities in some years. The following figures illustrate the principal destinations:

COPAL EXPORTS (TONS).

	1921.	1922.
United Kingdom	258	612
United States	865	2,199
Japan..	103	—
Australia	—	67

There is little doubt that the majority of the copal exported is the produce of the Dutch East Indies, and not of British Malaya, sold on the Singapore markets; there is, so far as we are aware, no information on record to show if copal is actually produced in any quantity in British Malaya. With regard to the imports of *Benzoin* and *Dragon's blood*, these are practically all the produce of Sumatra imported and sold in Singapore. Turpentine in 1921 was largely—about four-sevenths—from the United Kingdom, but in 1922 was imported from Dutch Borneo.

HONG KONG

Although Hong Kong itself is an island only 11 miles long and 2 to 3 miles wide, yet a very considerable volume of trade passes through it. As would be expected, the bulk of the import trade is from China, and exports from this port go to all countries, but mostly to South China, Philippine Islands, Japan, Australia, and the East generally.

The following figures, showing the chief oilseed and oil imports and exports, do not include imports arriving from ports in China further south than Swatow, and parts of the cargoes from Swatow, Amoy, and Foochow are not included.

	1922.	
	Imports (*Tons*).	*Exports* (*Tons*).
Coconuts	4,405	3,329
Ground nuts	19,840	15,363
Sesame	1,093	1,836
Melon seed	2,423	2,629
Other seeds	1,184	751
Lard	271	3,643
Ground-nut oil	12,362	9,708
Wood oil	29	1,900

It may be noted that 1922 trade was badly affected by the strike of Chinese coolies, etc., which completely paralyzed trade for nearly two months. Apart from that, ground-nut oil imports show a considerable falling off. The value of these imports in 1921 was £534,557 and in 1922, £233,320.

BRITISH BORNEO

Very little surplus is produced by the oilseed crops of North Borneo, and the only export of significance is of copra. Coconut-planting has made progress in the island, and the estimated area under coconut in 1914 of 11,700 acres had increased to 24,946 in 1919. In 1919, 1,579 tons of copra and about half a million nuts, and in 1921, 2,787 tons of copra, were exported. The Government encourages coconut cultivation by letting land for the purpose on special terms. The oil palm was introduced in 1883, but is not yet cultivated on a commercial scale.

The tung-oil tree grows in Borneo, but all the oil obtained appears to be used locally. The same is true of the illipé nuts (see p. 94), and it is doubtful if the exports of these nuts from Borneo include any appreciable quantities from British Borneo.

SARAWAK, also situated in Borneo, and adjoining the territory of "British Borneo," also grows coconuts, but the exports are not on a large scale and only reached 351 tons in 1921. Exports of seed under the name "mowra" are fairly considerable, but the exact nature of these seeds is doubtful. Possibly they are true illipé nuts or a species of *Bassia*. Exports of mowra in 1919 were returned as 6,693 tons and in 1920 as 1,047 tons.

WEI-HAI-WEI

This small Colony is of some importance as a centre of trade, and exports of ground nuts and ground-nut oil reach considerable proportions. Most of these go to Hong Kong for redistribution.

GROUND NUTS AND OIL: EXPORTS (TONS).

	Undecorticated.	*Decorticated.*	*Oil.*
1913	351	10,395	439
1919	—	15,894	226
1920	—	17,777	252
1921	3,362	21,312	1,560

The increase in oil export is noteworthy.

AFRICA

EGYPT

Agriculture in Egypt is dependent on the river floods and irrigation, and increases in areas under cultivation in recent years are due to the opening up of new irrigation schemes. The most important oil crop of Egypt is cotton, which has been cultivated from very early times. The area devoted to this crop is roughly one-fifth of the whole area cultivated, and about three-quarters of this area is in Lower Egypt. There has been an almost continual decline in yield of cotton per acre, and this has been ascribed to several causes, including poorness of new land sown following on increase of irrigation—overcropping and increased summer cultivation leaving less time for the land to lie fallow and get sterilized by the hot sun—and to general changes brought about in the soil by changes in irrigation.

The 1921 season was an exceptionally poor one for the crop, owing to bad preparation of the land and late sowing, but an improvement took place in 1922. Quite an appreciable amount of cotton seed is used in local oil mills and for seed purposes, and the total amount of seed crushed in Egypt has shown a steady increase in spite of variations in production.

The total area under cotton seed and estimated production is shown in the following table:

	Acres.	*Tons.*
1910	1,705,121	654,001
1915	1,231,139	433,245
1920	1,897,432	551,644
1921	1,339,113	302,054
1922	1,868,500	433,338

The total exports of cotton seed in 1922 amounted to 323,161 tons, and the difference between this figure and the production figure gives a rough idea of the amount of seed used in Egypt; about two-thirds of this was used for crushing and one-third for sowing.

The great bulk of the exported cotton seed now comes to the United Kingdom, but this has not always been so. In 1910 the United Kingdom took only just over half the Egyptian exports of seed, and Germany was making determined and successful efforts to increase her supplies from Egypt. During the War supplies to the Continent diminished and from 1916 to 1920 were practically non-existent, and though supplies to the Continent increased from 8,090 tons in 1921 to 19,600 tons in 1922, the United Kingdom still takes the bulk.

The other important oilseed crops grown in Egypt are sesame, ground-nut, and linseed, and the area occupied by these three crops in recent years was returned as:

1919–20	31,350 feddans.*
1920–21	28,798 "
1921–22	28,123 "

Sesame and ground nut occupy approximately equal areas, while linseed, which in 1921 occupied 5,765 acres, in 1922 diminished to 1,384 acres. Sesame has been cultivated in Egypt from very early times, but not very large quantities are exported, as considerable amounts are used for food in Egypt and a certain quantity (3,877 tons in 1920), used for crushing. Ground nuts also find extensive use in Egypt itself. Linseed cultivation has diminished with the increase of cotton; exports of linseed are negligible and some seed and considerable quantities of oil are imported.

EXPORTS (TONS).

	1921.	1922.
Cotton seed	254,471	323,161
Cotton oil	1,697	4,506
Cotton cake	93,393	121,128

The bulk of the cotton-seed, oil, and cake exports were to the United Kingdom in both these years. Cotton-seed exports were as follows:

COTTON-SEED EXPORTS.

Chief Destinations.	1921.	1922.
To United Kingdom	249,140	290,438
" Germany	3,461	27,125
" Other countries	1,870	5,598

In 1922, 117,453 tons of *cotton cake* and 3,371 tons of *cotton oil* went to the United Kingdom, 773 tons of cotton oil to Holland, and 214 tons to Palestine.

Exports of *ground nuts* were 2,265 and 1,510 tons respectively in 1921 and 1922; in 1922, 572 tons went to Syria, 462 tons to Palestine, 111 tons to Tripoli, and 70 tons to France; the latter country took nearly 300 tons in 1921. The exports of *sesame* seed and of *linseed* were as follows:

EXPORTS (SHORT TONS).

	1921.	1922.
Sesame seed:		
Greece	276	25
Palestine	330	800
Italy	851	25
Syria	275	138
Rumania	62	203
France	20	141
Linseed	19	17

* 1 feddan is approximately 1 acre.

The imports of oilseeds, oils, etc., were as follows:

IMPORTS (SHORT TONS).

	1921.	1922.
Oilseeds:		
Sesame seed	453	511
Ground nuts	376	14
Linseed	93	93
Coconuts	2,299	3,696
Oils:		
Olive oil	1,435	1,462
Cotton oil	14	340
Linseed oil	1,186	1,422
Coconut oil	2,299	3,694
Castor oil	360	304
Palm oil	673	570
Oil for soap	1,337	349
Turpentine	120	65
Animal oils	138	178
Rosin	351	279

Most of the linseed and palm oil is imported from the United Kingdom, while castor and olive oils are chiefly from France. In 1922, 1,326 tons of linseed oil came from the United Kingdom.

Imports of coconut oil are largely from British Eastern Possessions (2,559 tons in 1922), while 1,134 tons were from France.

ANGLO-EGYPTIAN SUDAN

The Anglo-Egyptian Sudan appears to be on the eve of considerable agricultural development; in the past the two great drawbacks have been (1) a dependence on the river floods for water, and (2) a lack of transport facilities. These two drawbacks are now being, at least partially, remedied.

The most important oil crops that are cultivated are cotton, sesame, and ground nut, and it is estimated that when the Gezira Irrigation Scheme is in full operation (which it should be in time for the 1925-26 crop), an additional area of 103,800 acres will be put under cotton. The provision of an assured water supply will have an enormous effect on the development of the country, not only in respect to cotton, but to all other crops. It is estimated that in 1922, 87,475 acres were under cotton, and in 1913, 123,000 acres under sesame, but the areas sown each year have so far depended very much on the extent of the floods.

The exports of oilseeds are given below:

	Previous Maximum.	1911–21 (*Average*).	1921.	1922.
Sesamum seed (tons)	12,593	7,476	12,593	10,723
Ground nuts ,,	4,203	1,857	4,203	2,695
Cotton seed ,,	9,290	6,013	9,290	9,042

The Eastern Sudan is being opened up by the Kassala Railway, and it is probable that very shortly this will mean the cultivation of more suitable land, probably for cotton.

Most of the exported ground nuts and sesamum seed goes to Egypt.

BRITISH WEST AFRICAN COLONIES

British West Africa includes the Gambia, the Gold Coast, Sierra Leone, and Nigeria; the importance of these Colonies as producers of oils and oilseeds is enormous, as many indigenous oilseed-bearing trees exist, such as the oil palm and the shea tree, while other crops, such as ground nuts and sesame, are cultivated.

The following figures serve to indicate the important position of British West Africa as a producer of oilseeds and oils for export:

EXPORTS OF THE MAIN OILSEEDS AND OILS FROM BRITISH WEST AFRICA (TONS).*

	Palm Kernels.	*Palm Oil.*	*Ground Nuts.*	*Shea Nuts.*	*Copra.*	*Sesame.*
1900	120,973	68,436	33,805	—	368	481
1910	230,678	87,610	59,451	4,462	755	48
1913	234,208	88,997	86,693	9,420	726	1,250
Maximum ..	278,149	108,036	129,446	10,084	780	2,853
Year	1919	1919	1920	1915	1911	1919
1921	195,716	53,235	110,154	5,770	287	1,234
1922†	228,207	89,958	86,868	6,717	171	1,433

Obviously the materials of chief importance are oil-palm products and ground nuts, an interesting feature being the enormous and rapid expansion of the trade in ground nuts due to increased cultivation in Northern Nigeria.

The following table indicates the share of each Colony in the exports of oil-palm products and ground nuts:

	1910-14 (*Average, Tons*).	1921 (*Tons*).	1922 (*Tons*).
Palm kernels:			
Gambia	479	302	450
Sierra Leone	44,358	40,409	49,029
Gold Coast..	11,488	1,651	Not available
Nigeria	174,236	153,354	178,728
Palm oil:			
Gambia	—	—	—
Sierra Leone	2,522	191	2,079
Gold Coast..	5,164	273	—
Nigeria	77,771	52,771	87,609
Ground nuts:			
Gambia	60,969	59,175	62,978
Sierra Leone	—	—	Negligible
Gold Coast..	—	—	Not available
Nigeria	8,195	50,979	23,890

* Up to and including 1919 from West Africa Report of Committee on edible and oil-producing nuts and seed. † Omitting Gold Coast (figures not yet available).

Nigeria is, therefore, the most important source of exports of palm kernels and palm oil, followed by Sierra Leone; and while Gambia was formerly the source of the bulk of the exports of ground nuts from British West Africa, Nigeria has almost equalled and bids fair to surpass Gambia.

The exports of other oilseeds, such as cotton seed, copra, shea nuts, and sesame seed, are relatively small, and will be referred to in the following notes on the different Colonies:

The Gambia.

The Gambia Colony and Protectorate consists of a narrow tract of country lying along the course of the Gambia River for about 250 miles, and extending some 4 miles only on each bank of the river. It is the northernmost of the British West African Colonies, lying between 12°10′ and 13°15′ north latitude. The total area is about 4,000 square miles, and is mostly low-lying land cut up with creeks and rivers, often thickly grown with mangroves. A large amount of farming is done by natives, who live in neighbouring French and Portuguese territories, and migrate to the Gambia annually to cultivate the land, chiefly with ground nuts.

The cultivation of ground nuts is on such an extensive scale that little or no attention is paid to other oilseed crops, though small quantities of palm kernels—chiefly from the Kombo and Fogni Provinces—are exported (see table, p. 209).

Cotton has long been grown in the Gambia, but is not of any importance at present.

The soil is mostly light and sandy, and therefore eminently suited to ground nuts. The low country is liable to floods, and only suited to rice. The ground nuts exported are of good quality, though slightly inferior to those shipped from the French territory to the north, from which "Rufisque" and "Cayor" nuts exported to Europe are the best grades.

A good crop of ground nuts in the Gambia amounts to about 44 bushels of nuts (in the shell) per acre, the bushel weighing from 25 to 31 pounds. The area under ground nuts has for many years been very large, and has grown steadily during the present century. In 1920-21 it was calculated that the area under this crop was about 120,000 acres. The figures for export show the growth of this industry.

Average Yearly Exports (Tons).

1900–1904	36,416	1910–1914	60,969
1905–1909	38,403	1915–1919	68,997

In recent years the exports are as follows:

	1920.	1921.	1922.
Tons	84,037	58,274	62,978
Value (£)	2,322,032	620,247	767,197

These exports of ground nuts are chiefly, if not wholly, exported in the shells, and are shipped chiefly to the United Kingdom and France. Shipments in 1922 were as follows:

To United Kingdom	30,705 tons.
„ France	22,716 „
„ Holland	6,715 „

There is an export duty of 20s. per ton on ground nuts. The exports of palm kernels have never been large, and only amount to 408, 302, and 450 tons in 1920, 1921, and 1922, the value in 1922 being £5,731.

Beeswax is also exported from the Gambia; over 53,400 pounds were exported in 1907, but figures for recent years are not accessible.

The imports of oils, etc., are mostly small, though it is curious to note in a country producing ground nuts (which are a source of edible oil) that fair amounts of edible oils are imported. In 1922 the principal imports of oils, etc., were as follows:

	Quantity (Gallons).	*Value (£).*
Cotton-seed oil	58,579	12,266
Ground-nut oil	814	206
Olive oil	657	409
Palm oil*	8,326	1,186
Oil, paint, and turpentine	2,725	646
Other edible oil	336	—

GOLD COAST.

The Gold Coast Colony is situated on the Gulf of Guinea, and has a coastline on the south of nearly 400 miles; it is bounded on the east by the former German Colony of Togoland, and on the west by French Guinea; the extreme northern boundary of the Northern Territory of the Gold Coast is the eleventh parallel, and adjoins the French Sudan. The coast is mostly low lying, with salt lagoons, the soil on the coast districts being gravelly or sandy; the country rises gradually inland to chains of hills with rich soil and dense forest vegetation. The northern portion is largely grassland interspersed with trees.

The rainfall in the low-lying plains in the eastern districts is small, but is abundant in the western hills and in the interior. At Accra, on the coast, the yearly rainfall is about 30 inches. There are several important rivers, such as the Volta, Ankobra, Tano, which are navigable to a varying extent—*e.g.*, the Volta for 50 to 60 miles.

Although both the oil palm and the coconut palm grow in the Gold Coast, the exports of copra have never been large, and the trade in palm oil and kernels has fallen off considerably in recent years, owing to the great increase in cocoa cultivation, which has diverted attention of the natives from other agricultural and forest products.

* From Sierra Leone.

The following table shows the exports of oil-palm products and of copra in recent years, in comparison with years before the War:

EXPORTS (TONS).

	1910.	1911.	1912.	1913.	1921.	1922.
Palm kernels	14,182	13,254	14,628	9,744	1,651 (£30,820)	Not available yet
Palm oil	8,179	6,441	5,778	3,141	273 (£7,717)	
Copra	755	779	620	629	443 (£10,489)	

Most of the palm oil shipped is of fairly high acidity—*i.e.*, it is "hard" oil—and includes such kinds as Accra, Saltpond, Winnebah, and Dixcove grades, and, together with kernels, goes chiefly to Liverpool.

The decrease in exports of oil-palm products is thus very considerable, and the Gold Coast, which was formerly a source of some importance with regard to palm kernels and palm oil, is now of small importance. One cannot attempt to foresee whether this country is likely in the future to regain her former position; up to the present cocoa has proved more profitable, and the future of the oil palm will depend on how far cocoa remains profitable, and on how the increasing demands for palm oil and kernels affect the markets.

There are many who consider the policy of "putting all one's eggs in one basket" is an unwise one, and that it is most desirable to exploit other products, such as the oil palm and coconut.

Coconuts are chiefly grown along the coast regions, copra being produced in the Kwitta district. Out of 443 tons shipped in 1922, 288 tons went to France, 95 tons to the United Kingdom, and 55 tons to Holland.

Shea-nut trees are abundant, particularly in the Northern Territories (see p. 92), and shea butter is used by the natives; the opening up of the Northern Territories and the provision of means of transport should in the future enable large exports of shea nuts to be made.

Copal of medium quality is also exported from the Gold Coast, but in very irregular quantities from year to year. The following are exports in recent years:

	1917.	1918.	1919.	1920.	1921.	1922.
To United Kingdom ..	2,306	1,963	12,984	7,576	8,002	Not available yet
„ France	—	—	764	—	—	
„ U.S.A.	—	—	—	76,560	—	
Quantity (lbs.)	2,306	1,963	13,748	84,136	8,002	
Value (£)	24	38	174	2,779	124	

The imports of oils, etc., to the Gold Coast are small, the only item of any appreciable magnitude being lard and lard compounds, which amounted to nearly 100 tons, valued at £12,549, in 1922 (import duty on this 8s. per 100 pounds).

SIERRA LEONE.

Sierra Leone is bounded on the north and west by French Guinea, and on the east by Liberia, and covers an area of over 30,000 square miles; most of the country is undulating and well-watered land of a fairly fertile character, traversed by short ranges of mountains, generally running north and south.

The oil palm and its products are of great importance; the oil palm is distributed throughout the country from the coast into the interior, but flourishes best—as in other parts of West Africa—on the moist lands near the rivers, and in the extreme north of the country, where the rainfall is small, is only found near streams.

Coconuts, ground nuts, cotton, and sesame seed are also grown, but with the exception of sesame seed, of which small quantities are exported (*e.g.*, 23 tons, including 10 tons to the United Kingdom in 1922), all the produce is generally consumed locally. Ground nuts were formerly grown in the Bullom district for export, but have not been exported for some years. The exports of palm kernels and palm oil are as follows:

ANNUAL AVERAGE (TONS).

	1900–04.	1905–09.	1910–14.	1920.	1921.	1922.
Palm kernels	22,495	37,018	44,358	50,425	40,409	49,029
Palm oil	790	2,079	2,522	2,066	191	2,076

The exports of palm oil in relation to exports of palm kernels are interesting; the exports of oil are only about one twenty-fifth the exports of kernels, while other countries, such as Nigeria, export oil to the extent of one-third or even one-half the amount of kernels; hence the consumption of palm oil in Sierra Leone must be very considerable.

In 1922 the exports of palm kernels are nearly 9,000 tons larger than in 1921, partly owing to the abolition of the £2 a ton preferential tax, but the value dropped by nearly £12,000; fluctuations of this kind are of considerable influence on the prosperity and trade of countries where the native's power to buy imported goods depends on the payment he receives for staple products such as kernels.

Oil-palm products are largely carried by the Sierra Leone Railway (26,508 tons of kernels in 1922), and shipped through Freetown and Sherbro; shipments in 1922 were as follows:

	Palm Kernels (Tons).	*Palm Oil (Tons).*
From Freetown	34,789	1,169
„ Sherbro	14,240	907
Total (tons)	49,029	2,076
Value (£)	722,403	61,786

Of the exports, 47,646 tons of kernels and 1,819 tons of palm oil were shipped to the United Kingdom, while Belgium took nearly 1,000 tons of kernels. It

is said* that the quality of Sierra Leone kernels has improved considerably since the appointment of an Inspector of Produce; according to the Sierra Leone Government's "Natural Products Ordinance," it is now an offence to sell or deal in palm kernels which have been insufficiently cleaned or have been soaked or adulterated, and the enforcing of this regulation and numerous prosecutions have been very beneficial to trade. Shipment of 36 tons of edible palm oil was made to the Gambia in 1922. The export duty on palm oil has been £1 0s. 10d. per ton since 1922.

In 1922 it is of interest to note that a scale pest on coconut palms also attacked oil palms, but was rapidly controlled, and it was anticipated that the pest would soon be eliminated.

Copal is also a product of Sierra Leone, but the trees have been over-tapped in the past and so many killed that the export of copal has been prohibited by ordinance since 1920, and no exports are now recorded. The following are exports to the United Kingdom:

Year.	*Cwts.*	*Year.*	*Cwts.*
1918	260	1921	—
1919	19	1922	8†
1920	458		

It is rather curious to note that Sierra Leone copal still appears (in 1924) on the London market, and one wonders if this is old stock or not really Sierra Leone produce, or if copal produced in Sierra Leone goes over the border to adjacent territories and is exported thence, and not through Sierra Leone ports.

NIGERIA.

Nigeria, as at present constituted, includes the former divisions of Southern and Northern Nigeria, and comprises an area of nearly 35,000 square miles. Southern Nigeria possesses a long stretch of sea-coast intersected by numerous rivers, of which the most important is the Niger River. Nigeria is adjacent to Dahomey and Guinea on the west, and the Cameroons on the east; the northern border of North Nigeria lies along the French Sudan. The southern portion of the country is, as mentioned above, intersected by rivers, and consists of a large zone with a heavy rainfall—the wet zone—with large areas of level moist land on which the oil palm is very abundant; north of this is an intermediate zone with a lower rainfall and less heavily forested, while the northern province is a dry zone, principally of grassland studded with trees which become more stunted as one travels northward.

In the northern parts the soil is of a light nature suited to ground nuts, which are now grown and exported in enormous quantities, the transport facilities afforded by the railways constructed in recent years having greatly assisted this industry.

* *Sierra Leone Trade Report*, 1922.

† By special license.

The chief oilseeds and oils produced in Nigeria are, therefore, palm kernels, palm oil, and ground nuts; cotton-growing has in recent years assumed considerable importance, and fairly large amounts of cotton seed are now exported. Sesame (benni) seed is also largely grown, though comparatively little is exported. Copra is also produced, chiefly in the coastal districts, but the exports are insignificant. There are various other indigenous oilseeds, but so far only shea kernels have been exported in any appreciable quantity. These are derived from the Ibadan district of South Nigeria, and probably also the Ilorin district of North Nigeria.

Beeswax is also produced and exported, though only in small quantities, while exports of copal in recent years are of very insignificant importance.

Palm oil and kernels are thus chiefly products of the southern province in the coast regions, and along the courses of the many rivers. Nigerian palm oils are largely high-grade soft oils of low free fatty acid content, and include the high-grade "Lagos" oil, which is as a rule only equalled in value by fine red Sherbro kinds (Sierra Leone).

The high quality of such oils as Lagos oil is due to the native methods of preparation and depends chiefly on the employment of fresh fruits, which are worked up soon after gathering, and which are not allowed to ferment. Such oils are readily saleable at higher prices than hard oils, as they are suitable for refining for edible purposes, and there can be no doubt that it is advisable to encourage their production, as the demand is likely to increase considerably.

The cultivation of ground nuts in Nigeria is on a very large scale, and enormous quantities have been exported in recent years from Northern Nigeria, while ground nuts are also grown in the dry parts of the southern province. The soil and climate of the northern province are admirably suited to ground nuts, and the population of the ground-nut belt amounts to some 4 millions. The possibilities of expansion are very considerable, and exportation is likely to grow with increased facilities of transport by railway.*

Kano is the centre of the ground-nut trade, the nuts being brought to market by camel, donkey, or ox transport, and carried to coast by rail; a good deal of the supply comes in from adjacent French territory. The export trade is almost entirely in decorticated nuts in order to save cost of rail transport. Shelling is effected chiefly by women with large wooden mortars and pestles. Labour is cheap, and it is estimated that 1 ton of nuts, giving 0·62 to 0·65 ton of kernels, can be shelled for about 10s. Decortication by machinery gives kernels of better quality (less kernels are broken), but is rather more expensive. Unless the price paid to the natives for nuts in the shell is at least 66 per cent. of that for decorticated nuts, the natives will prefer to shell them, and it would probably be necessary to pay nearly the same price for nuts in the shell as for decorticated nuts, if any large trade in whole nuts were to be worked up. There is no local demand for oilcake, and this fact, together with the difficulty of providing containers for oil, militates against local oil production for export, though it is considered that a local soap factory might be worked with good prospects.

* P. H. Lamb, *Ann. Rept. Agric. Dept. Nigeria*, 1921, p. 25.

Cotton has been grown for a long time in Nigeria, and in recent years long staple cotton of the American Upland type has been introduced, and is rapidly replacing native cotton. The improved variety gives a heavy yield of cotton, which sells at a good price in Liverpool; in 1921, 22,527 bales were exported. Considerable amounts of cotton are used locally.

Exports of oilseeds and oils from Nigeria are shown in the following table:

		1913.	1920.	1921.	1922.
Palm kernels	Tons	174,718*	207,010†	153,354†	178,728
	£	3,109,818	5,717,979	2,831,688	2,809,655
Palm oil	Tons	83,089‡	84,856	52,771	87,609
	£	1,854,384	4,677,444	1,655,914	2,676,241
Cotton seed	Tons	5,887	403	8,579	2,409
	£	14,331	—	43,245	10,408
Ground nuts	Tons	19,288	45,409	50,979	23,890
	£	174,716	1,119,688	1,111,822	480,992
Shea products (kernels and butter)	Tons	9,560	9,905	5,770	6,944
	£	74,471	122,532	63,952	74,394

The chief port of shipment of all these products, as a rule, is Lagos. The following table serves to show the principal exports in 1921, and the ports from which they were shipped:

SHIPMENTS, 1921 (TONS).

	Palm Kernels.		*Palm Oil.*		*Cotton Seed.*		*Ground Nuts.*		*Shea Products.*	
	1921.	1922.	1921.	1922.	1921.	1922.	1921.	1922.	1921.	1922.
Lagos ..	58,048	69,762	4,352	12,929	8,486	2,308	39,073	20,620	182	106
Koko ..	4,720	8,912	769	2,581	—	—	—	—	—	—
Sapele ..	2,632	3,693	1,260	2,099	—	—	—	—	—	—
Warri ..	14,548	15,609	5,994	5,916	—	—	232	440	270	734
Burutu ..	24,022	20,833	4,820	9,725	93	101	11,674	2,830	5,318	6,104
Akassa ..	—	2,055	—	1,374	—	—	—	—	—	—
Degema ..	6,922	9,446	5,089	7,679	—	—	—	—	—	—
Port Harcourt	10,952	12,655	9,950	18,656	—	—	—	—	—	—
Opobo ..	13,906	15,565	15,311	15,946	—	—	—	—	—	—
Bonny ..	546	948	596	774	—	—	—	—	—	—
Calabar ..	17,058	19,245	4,707	9,930	—	—	—	—	—	—
Total ..	153,354	178,723	52,771	87,609	8,579	2,409§	50,979	23,890	5,770	6,944

The exports of ground nuts in 1922 are considerably smaller than in 1921, owing to partial failure of local food crops, and also to the prices, which were considered to be low.

* 1913, 5,412 tons palm-kernel cake.

† 1920, 1,005 tons palm-kernel cake and 3,493 tons palm-kernel oil; 1921, no palm-kernel cake or palm-kernel oil.

‡ Not including palm-kernel oil (3,857 tons, value £129,442).

§ All to United Kingdom.

The following table shows the destinations of the exports of ground nuts, palm oil, and palm kernels from Nigeria in 1921 and 1922:

	Ground Nuts.		Palm Oil.		Palm Kernels.	
	1921 (per Cent.).	1922 (per Cent.).	1921 (per Cent.).	1922 (per Cent.).	1921 (per Cent.).	1922 (per Cent.).
United Kingdom ..	30	27	88	72	98·9	94·6
France	9	30	—	—	—	—
Germany	39	28	1·2	1·5	0·1	4·7
Italy	9	6	1·8	6·5	—	—
Holland	2·5	4	—		—	—
Belgium	7	3·5	—			—
United States ..	—	—	2·5	19·4		—

The whole of the exports of cotton seed went to the United Kingdom. Only 27 per cent. of the ground-nut exports in 1922 was to the United Kingdom, the remaining 73 per cent. going to the Continent, chiefly to Germany and France. The palm-oil exports are chiefly to the United Kingdom, but the export of nearly 20 per cent. (over 17,500 tons) direct to the United States of America in 1922 is a point of interest. Almost all the palm kernels now go to the United Kingdom, but Germany is again beginning to absorb some quantity from Nigeria.

Exports of other products, with details of shea products, are as follows:

		1913.	1920.	1921.	1922.
Copra	Tons	96	222	116	171
	£	1,891	8,557	2,618	3,630
Sesame seed	Tons	1,214	1,150	1,196	1,410*
	£	9,245	15,789	16,918	19,732
Shea butter	Tons	140	530	265	227†
	£	4,404	21,741	9,121	8,998
Shea nuts	Tons	9,420	9,375	5,505	6,717‡
	£	70,427	100,790	54,831	65,396
Copal	Cwts.	376	43	121	15§
	£	323	98	285	15
Beeswax	Cwts.	115	145	—	71
	£	400	797	—	305

Copra is, therefore, of small importance, and it is rather curious that copra has not attained any appreciable importance in West African Colonies, as there are considerable areas suited to coconut cultivation. No doubt the small interest taken in this is largely due to the abundance of the oil palm.

Sesame cultivation might well be extended and larger quantities of seed exported to Europe. Copal is obviously of small importance, and although Nigerian copal is generally not of good quality, it would seem that some effort

* 555 tons to United Kingdom, 774 tons to Germany.
† 85 tons to United Kingdom, 98 tons to Gold Coast, 40 tons to Belgium.
‡ 6,317 tons to Belgium, 400 tons to United Kingdom.
§ All to United Kingdom.

might be made to ascertain whether the quality could not be improved, and exploitation increased. From the figures quoted for exports and values, it would appear that these are merely nominal values (for Customs purposes), and cannot represent the market value, even of a poor grade of copal.

Beeswax exports are small, and further steps might well be taken to encourage production.

The exports of shea butter are quite small, and those of shea nuts (really decorticated kernels) have declined appreciably during 1921 and 1922. Shea kernels certainly sell at rather low prices in the European markets, but it should be possible to increase the popularity of shea butter and the demand for kernels, and better prices seem likely in the future, though if large supplies from the Northern Territories of the Gold Coast can be marketed, these will doubtless influence the market.

UNION OF SOUTH AFRICA

The Union of South Africa comprises the provinces of:

	Area.	
Cape of Good Hope	276,966	square miles.
Natal	35,284	,,
Transvaal	110,450	,,
Orange Free State	50,389	,,
Total area of Union	473,089	,,

A very small proportion of this area is under oilseed crops, far less than will supply the requirements of the Union, and therefore the imports of these products assume comparatively large proportions, and the exports are very small. The only oil crops that are grown to any extent are sunflower, cotton, a little ground nut, and some linseed. The position with regard to the treatment of the oilseed produced in the country is not satisfactory; for example, difficulty is experienced in disposing of the linseed produced, while consumption of linseed oil in the Union is estimated at something like 300,000 gallons a year, and the whole of this quantity is imported. It is said that suitable oil-mill machinery is available, and, in fact, early in 1922 an attempt was made to express the oil, but was soon abandoned. Also, cotton seed has in the past been destroyed, while a considerable quantity of cotton oil is imported. It would thus appear that a great opportunity arises for oil mills to treat such home-grown seed.

Areas under oil crops are given in the *Official Year Book* for 1922 as:

	Ground Nuts (Acres).	*Sunflower (Acres).*
Cape Province	203	292
Natal..	2,087	1,463
Transvaal	16,572	7,390
Orange Free State	190	1,577
Total	19,052	10,722

The area under linseed is normally about 24,000 acres, but it has varied considerably from year to year.

The exports of seed for 1922 were:

Cotton seed..	66 tons.
Sunflower seed	214 ,,

Linseed does not appear among the exports, while the exports of vegetable oils are very small indeed.

South African linseed is said to be of a specially good quality. It has been exhibited at various trade exhibitions, and it is expected to command a ready sale when it is better known. In order to find a ready market for the excess of ground nuts produced, it is very desirable that South Africa should, like West Africa, get a name for quality. The importance of this is emphasized in the *Journal of the South African Department of Agriculture*, where it is advocated that at first sales on sample should be made, and that great attention should be paid to keeping delivery up to sample.

IMPORTS OF SEEDS AND OILS IN 1922 (TONS).

Copra (valued at £70,996)	3,090
Coconuts..	602
Palm kernels	61
Ground nuts	669
Other seeds (chiefly from Kenya and Portuguese East Africa)	1,429
Cocoa butter	37
Cotton oil	1,111
Coconut oil (mostly from Ceylon)	1,082
Linseed oil (mostly from the United Kingdom)	1,264
Palm and palm-kernel oil (mostly from the United Kingdom)	106
Colza and rape oils	28
Other vegetable oils	120

For details of the whaling industry of South Africa, see Part I., p. 106.

RHODESIA.

Very little data is available for Northern Rhodesia, and the production of oilseed crops is not big enough to allow of any appreciable exports. The data and figures given below refer to Southern Rhodesia.

The only two crops that are cultivated to any large extent are ground nut and sunflower. These two crops take respectively fifth and sixth places in importance in considering total cropped areas, and the acreage is as follows:

	1920–21 (*Acres*).	1921–22 (*Acres*).
Ground nuts	4,414	5,432
Sunflower	3,974	2,722
Cotton	802	135
Linseed..	52	114

Cotton-growing has not prospered in Rhodesia, except in parts of Zambesi, as the conditions of labour, freight, storage, etc., do not allow sufficient profit.

The castor plant is indigenous to Rhodesia, but experiments in cultivation, which were started in 1912, have not been satisfactory. It is probable that the plant would thrive better in lower and warmer districts than those tried hitherto. However, *the soil and conditions best suited to castor are those which also produce the best maize, which is a more valuable crop.*

The climate and soil of Rhodesia are distinctly favourable for oilseed crops, and the limiting factors in production are the questions of markets and freights. The country responded well to the appeal for production within the Empire, but the small activity of home buyers has made disposal difficult. The farmers are not in the position of the big commercial houses, and cannot dispose of their produce on such a satisfactory basis.

The value of oilseed crops in rotation with maize is becoming more widely appreciated, and ground nuts were exported overseas for the first time in 1920. Ground nuts have not yet, however, appeared as a separate item in the export figures. There are two oil mills in operation, and these have dealt chiefly with ground nuts. The cattle cake produced is readily disposed of, but an outlet for the oil has not been so easy to find. Since South Africa imports a considerable quantity of liquid vegetable oil, it would appear that a market in that country might be found for the Rhodesian surplus.

EXPORTS, 1922.

Castor oil	8 tons.
Linseed oil	3 „
Sunflower seeds (348 tons to the United Kingdom, 53 tons to U.S.A.)	414 „

IMPORTS, 1922.

Linseed oil	59 tons.
Castor oil	9 „

NYASALAND.

Nyasaland is essentially an agricultural country, and its chief oilseed crop is cotton seed. Between 20,000 and 30,000 acres are estimated to be under this crop, and the production of seed is about 1,000 tons a year. The cotton industry received a setback during the War, partly owing to the necessity of providing food-stuffs for the local forces, and partly owing to the fact that tobacco cultivation was more remunerative owing to the high prices commanded by tobacco; and in 1912-13 and 1913-14, owing to climatic conditions. Renewed interest in cotton is, however, now being taken.

Ground nuts are also cultivated and a small proportion exported. It may be noted that soya beans are cultivated to some extent, but that the crop is not regarded as likely to repay cultivation for export, though valuable as a rotation crop, and as a green manure to replenish the nitrogen of the soil.

KENYA AND UGANDA.

Since 1917 the Customs Departments of these two countries have been amalgamated, and it is convenient to consider them together.

The oilseed crops cultivated are cotton, sesame, ground nut, and coconut, and to a less extent castor and linseed. Perhaps the most outstanding agricultural feature is the very successful state of the cotton industry in Uganda. Until quite recently the cotton seed was largely wasted, but it is now the chief oilseed exported, and the cultivation of cotton has brought prosperity to Uganda beyond all anticipation. Cotton is also grown in Kenya, but in Uganda cotton-growing has practically reached the limit permitted by present transport facilities, and a scheme involving some £8,000,000 has been sanctioned to improve and extend the railways of Kenya and Uganda.

EXPORTS FOR YEARS ENDING MARCH 31 (TONS).

	1921.	1922.
Cotton seed	3,230	4,117
Ground nut	176	71
Sesame	3,223	1,384
Copra	467	1,660

Exports for Uganda alone for the years ending December 31, 1921 and 1922, are given as follows:

	1921 (*Tons*).	1922 (*Tons*).
Cotton seed	4,865	2,123
Sesame seed	1,003	2,796
Ground nuts	2	507

From a consideration of these figures, it is evident that cotton seed exports from Uganda increased greatly in the latter part of 1921. The bulk of the cotton seed is exported to India and the United Kingdom, and most of the sesamum to India, France, and Australia. The copra goes to Zanzibar and France.

The extension of the Uganda railway to Jinja will greatly improve the transport conditions, and export of cotton seed should soon reach a substantial figure. It is stated that at present some 20,000 tons of the seed are burned every year owing to lack of transport.

Sesame is chiefly cultivated by the natives; the export of seed in 1922 was larger than that of cotton seed.

Linseed does not appear among the exports, though considerable areas are cultivated as a source of fibre, and production of seed in Kenya in 1920-21 was estimated at 2,100 tons.

The coconut is only planted along the coast districts, but its cultivation has extended considerably, particularly under European control. The exports in 1921 showed a decrease, however, which is attributed partly to the small European demand and low price obtainable in the Colony, which, during the last

quarter of 1921, was only about half that of the previous quarter. The yield in 1919-20 was estimated at 223,889 nuts in European plantations, and 1,527,076 nuts and 130 tons of copra for native areas. A large proportion of the exported nuts goes to South Africa.

Castor seed is also grown, but in 1920 and 1921 the exports were small. The latest figures, however, indicate that a satisfactory recovery is taking place, and for the nine months March to December, 1921, exports are given at 737 tons.

MAURITIUS AND DEPENDENCIES

The only two oleaginous crops that are of any importance in Mauritius and its dependencies are the coconut and ground nut, and of these the coconut has, in the past, been chiefly confined to the lesser dependencies, known as the Oil Islands, where it is the main industry. Latterly, however, the idea of extending plantations on Mauritius itself has engaged the attention of the authorities, and the district of Pas Géométriques, on the windward side of the island, has been fairly extensively planted. The report in 1920 was that the conditions of the plantation was "promising." The total area under coconut was given for 1921 as 809 acres, and the total production of coconuts was probably in the neighbourhood of 300,000 to 400,000. A certain amount of ground nut is cultivated, but in 1921 the total production only reached 300 tons.

The total population is placed at nearly 400,000, and since the home production of oil crops is so small it is evident that there must be considerable import, and this is of oil rather than seed.

EXPORTS OF COPRA AND POONAC FOR 1921 AND 1922 (TONS).

1921	193
1922	597
1922 (re-exported)	258

Most of the copra went to South Africa and the rest to the United Kingdom.

The chief imports of vegetable oils for 1921 were: rape oil, 635 tons; linseed oil, 196 tons; castor oil, 167 tons; and ground-nut oil, 451 tons. Except for nearly 600,000 coconuts and 222 tons of ground nuts, imports of oilseeds are very small.

THE SEYCHELLES ISLANDS

The main industry of these islands, which are situated between the east coast of Africa and India, is coconut cultivation; in fact in 1916 it was estimated that about 60 per cent. of the total area—*i.e.*, 23,530 acres, were under coconut. Since 1913 figures for the total yield of nuts have been recorded, and between 1913 and 1921 this has been between 23 and 37 millions, except that in 1918 it fell to 11 and in 1917 to 20 millions.

The crop for 1921 was put at 26,362,965 nuts, an increase of more than a million over the 1920 output. The small output in 1918 was attributed

by the Director of the Botanical Station to exhaustion of the soil; in 1919 the cleaning of the plantations was made compulsory, and the beneficial results have since been manifest. There has been an increase in the number of trees planted, so that a bigger out-turn should soon result. In the Seychelles the coconut trees do not flower regularly, and this causes irregularity in the crop.

Owing to the fact that the prices obtained for copra and for cinnamon-leaf oil (the other main industry of the islands) have been low (1920), and that the price of imports had not fallen in proportion, the planters have had little money to spend on bettering their estates. There is little doubt that more care is needed in selecting seed for planting, and in improving cultivation, particularly where the plantations are on the sides of hills and the depth of soil small.

EXPORTS FOR 1920 AND 1921.

	1920.	1921.
Coconuts (number)	95,847	609,965
Copra (tons)	2,561	2,579
Coconut oil (tons)	84	127

ZANZIBAR AND PEMBA.

The most important oleaginous product of this island and of Pemba is the coconut. The number of coconut palms in the two islands has been estimated at 2½ millions, and copra is produced in considerable quantities, some 7,000 to 8,000 tons a year being at present manufactured. On the whole this copra does not compare well in quality with Cochin and Ceylon copra, chiefly owing to inefficient methods of drying. A certain amount of sesamum and castor seed is also produced. The volume of trade passing through Zanzibar is considerable, and includes a large proportion of the exports from Tanganyika and Portuguese East Africa. The chief trade figures for 1922 are given below:

	Imports (*Tons*).	*Exports, including Re-Exports* (*Tons*).
Coconuts	3,600	904,106
Copra	5,331	12,673
Ground nuts	1,020	831
Sesame	1,933	1,365
Castor	701	621
Beeswax	590	—
Copal	212	164

Most of the imported copra is from Tanganyika and Mafia, while more than half the exports go to France.

Very nearly the whole of the ground-nut imports are from Tanganyika, and, again, the bulk go to France.

The shipments of beeswax and copal are chiefly to the United Kingdom.

TANGANYIKA TERRITORY

The chief oilseed crops cultivated in this country are ground nuts, sesamum, copra, and cotton. About 30,000 acres were under cotton in 1921, but no production figures are available for the other crops. The exports pass largely through Zanzibar.

EXPORTS, 1921 (TONS).

Ground nuts	3,369
Copra	3,492
Sesamum	896
Cotton seed	63

Ground-nut cultivation is on the increase.

AMERICA

CANADA

THE climate is, in general, too rigorous except for the more hardy oilseed crops, such as linseed, rape, and sunflower. Linseed is of great importance, and although no figures are available for production of sunflower seed, this crop is gaining ground, particularly in Saskatchewan, where it is becoming more of a staple crop each year. Before the War flax was cultivated practically entirely for seed purposes, but latterly considerable interest has been taken in the production of fibre, and in 1921 some 6,500 acres were sown for fibre purposes. The total area under linseed in Canada in 1922 was 565,479 acres. On comparing this area with those of previous years it will be seen that the maximum area was in 1912, and this rapidly fell off to a minimum in 1915, and increased again to a second but smaller maximum in 1920. Since that date the area diminished, but the 1923 figures show a small increase.

	Area (Acres).	*Yield (Tons).*
1900	23,086	4,305
1910	582,326	106,113
1912	2,021,900	653,241
1915	463,359	152,848
1918	1,068,120	151,378
1920	1,428,164	199,940
1921	533,147	102,794
1922	565,479	125,212
1923	629,938	—

The provinces of Canada supplying the bulk of the seed are Alberta, Saskatchewan, Manitoba, Ontario, and Quebec, and of these the first three contributed, in 1922, 99 per cent. of the whole. These provinces are adjacent to the States of North Dakota and Montana, the largest flax-growing provinces of the United States of America.

The actual areas in 1922 were:

Alberta	22,186 acres.
Saskatchewan	466,177 „
Manitoba	66,680 „
Ontario	4,556 „
Quebec	5,880 „

Practically the whole of the linseed exported goes to the United States of America. A large proportion of the linseed produced is exported, and exports of linseed in recent years were as follows:

1918–19	47,274 tons.
1919–20	28,200 „
1920–21	35,103 „
1921–22	90,781 „

Exports of oilcake in 1921-22 amounted to 20,695 tons, and of vegetable oils 1,631 tons; of fish oils 1,596 tons; and of animal oils 558 tons, and of tallow 821 tons.

Imports, as would be expected, are more varied.

IMPORTS, 1922 (TONS).

Oils:	
Linseed	186
Cotton	20,495
Coconut, ground nut, etc. (technical)	5,501
Ground nut and soya	423
Palm and shea butter (edible)	10
China wood oil	968
Lard	4,058
Lard compound	1,378
Oleo-margarine	608
Oilcakes and meals:	
Palm and palm kernel	41
Cotton	2,511
Linseed	2,514
Soya	237

NEWFOUNDLAND

The only oleaginous products of importance are cod-liver, fish, whale, and seal oils. In 1922 the exports were: seal oil, 1,730 tons; whale oil, 5 tons; cod-oil stearine, 112,127 pounds (see also p. 103).

BRITISH HONDURAS

The coconut industry is the most important agricultural industry in the Colony. The soil and climate are suitable and the trees usually thrive well. It is found that trees on the coast belt, as a rule, come into bearing after five years, while they require eight years on the inland plantations. Considerable difficulty is found in securing sufficient freightage, and producers usually have to sell to local buyers instead of shipping themselves. Up till 1920 very little copra was made and the husks have been mostly wasted. In 1922, 200 tons of copra were exported and 6,653,643 coconuts, and in 1923 the exports for the first ten months were 796 tons copra and 4,006,671 coconuts. It is evident, therefore, that the production of copra is on the increase. It may be noted that a small soap factory has been opened which uses cohune-nut oil as its raw product.

The cohune palm (*Attalea cohune*) is abundant in the Colony, but the difficulties of shelling the nuts and of transport appear to have prevented any considerable exploitation of this material. Cohune kernels yield an oil* very similar in character to palm-kernel or coconut oil, and, if shipped in good condition, are readily saleable.

* *Bull. Impl. Inst.*, 1914, **12**, 237.

BRITISH WEST INDIES

JAMAICA.

Jamaica carries on a large coconut industry, the number of acres under coconut in 1919 being given as 37,260. 1921 was a bad year for trade, owing to difficulties of finding a market, but since then the industry has developed considerably. Recent figures are as follows:

EXPORTS.

	Coconuts (*Number*).	*Copra* (*Tons*).
1920..	28,246,240	654
1921..	24,224,448	723
1922..	30,394,441	975
1923 (January 1 to December 1)..	22,284,301	2,229

These figures indicate that the production of copra is increasing at the expense of the nuts exported.

Cotton is cultivated in Jamaica to a certain extent, but not so much as formerly, and there appear to be no exports of seed.

ST. KITTS, NEVIS, AND ANGUILLA.

These three islands produce cotton and coconuts. Some 5,000 to 6,000 acres are usually devoted to cotton, but in 1921-22 the area diminished to 2,500. Exports of seed in 1922 amounted to 199 tons. The coconut industry is of recent development in these islands. In St. Kitts the area under coconuts extended in 1921 to 600 acres, about 300 of these being then in bearing, and 342,700 nuts were exported.

ANTIGUA.

Cotton is cultivated to a limited extent, and in 1922 the area under this crop was 391 acres, producing 56 tons of seed. Coconuts are not sufficiently grown to allow of an export trade, but enough practically to satisfy local demand. They are a crop capable of development, as a considerable area in the island is suitable for their growth.

MONTSERRAT.

This island grows a considerable amount of cotton, and the area under this crop is usually between 2,000 and 3,000 acres. In 1921-22 the area is given as 2,069 acres, but this does not include the land of small growers who do not sell the seed; otherwise practically all the seed appears to be exported. In 1921-22 exports amounted to 439 tons, and in 1922 to 510 tons.

DOMINICA.

The island is chiefly devoted to the lime industry, but the inhabitants are also interested in coconut cultivation. The annual production of nuts is probably in the neighbourhood of a million, but there is considerable local consumption,

and in 1921, 299,787 were exported, and in 1922, 214,289. Dominica appears to be very well suited to coconuts, and it is unfortunate that so little attention is given to their cultivation.

St. Lucia.

Great hopes are entertained of the coconut industry, and cultivation is extending. The area under coconut in March, 1922, was about 5,000 acres. In 1922, 68 tons of copra and 107,185 coconuts were exported, and in the first ten months of 1923, 78 tons of copra and 91,745 coconuts.

St. Vincent.

This island produces cotton, ground nuts, castor seed, and coconuts. The area under cotton in 1920-21 was 7,965 acres, in 1921-22, 3,978 acres, and the production of seed for these two years was estimated at 405 and 451 tons respectively. The most recent figure available for the area under coconut is for 1915-16, at 2,000 to 3,000 acres, and progressive increase is said to have occurred since then.

Ground nuts have recently become an important crop, and cultivation appears to be on the increase. The castor plant only came into prominence during the War, and no figures of production are available.

Exports.

	Cotton Seed (*Tons*).	*Ground Nuts* (*Tons*).	*Copra* (*Tons*).	*Coconuts* (*Number*).
1920..	14	118	10	16,448
1921..	—	55	40	13,339
1922..	150	12	99	700
1923 (first nine months) ..	150	152	97	100

Barbados.

The chief—in fact the only—oil crops for which any statistics are published are cotton and coconut. In 1908, 7,194 acres were returned as under cotton. Cultivation then diminished to a minimum in 1917 of 980 acres. Since then an increase has taken place, and in 1922-23 the area is given as 2,767 acres. The exports of seed are, however, negligible, for practically all the seed except that needed for sowing is treated locally for the production of oil and meal. The number of coconuts produced in 1921 was estimated at 1,305,713, but no exports of either coconuts or copra appear to have taken place.

Grenada.

The area under cotton appears to have remained fairly constant for a considerable number of years, and the exports of cotton seed have also done so. The total area under this crop in 1922 is given as 3,200 acres and the exports as 282 tons.

So far, little attention is devoted to coconut-growing, but in view of the fact that some of the land is more suitable for coconut than cocoa, the Government is encouraging cultivation.

Trinidad and Tobago.

The coconut industry has reached considerable dimensions in these islands, and coconuts, copra, and coconut oil are all exported. There are six factories producing oil, and the output is usually in the neighbourhood of 600 tons, but production is influenced to a certain extent by the relative prices for the three products ruling at the time.

	Exports. *Coconuts* (*Number*).	*Copra* (*Tons*).	*Coconut Oil* (*Tons*).
1920	24,125,100	953	11
1921	21,550,993	1,873	31
1922	18,699,361	4,209	200
1923 (first eleven months)	11,565,380	5,006	—

The 1922 exports represent approximately 47 million nuts, a marked increase over the previous year, and the exports of nuts, copra, and coconut oil for that year were valued at £179,159.

A limited amount of cotton is cultivated, but conditions are not very favourable to this crop, and exports are small. In 1922, 10 tons of cotton seed were exported.

Bahamas.

No statistical data are available for these islands. Coconut plantation increased during the War, and considerable exports took place to the United States of America, and some of the islands are now said to be doing well with coconuts.

BRITISH GUIANA

In this country, which is approximately of the size of Great Britain, only an area equal in size to one-fifth that of Kent is cultivated, and the chief crops grown are sugar, rice, coconuts, and limes. The area planted with coconuts is difficult to estimate with any exactness, but the figures available show a continuous increase from 1904 to 1918, and after that there is a slight decrease.

1904	5,140 acres.
1910	9,761 „
1915	17,920 „
1918	29,400 „
1921	26,321 „

Although there are large tracts of waste land suitable for coconut cultivation, planting appears to have ceased (1922); production is, however, likely to increase for some years as the trees planted in previous years come into bearing.

The number of coconuts produced is given for 1920 as 21,753,000, and a large proportion is used locally for production of oil or directly as food.

Exports of coconuts are as follows:

1918	1,516,190
1919	4,693,659
1920	3,121,195
1921	2,760,632
1922	2,130,856

It may be noted that the exports for 1923, January 1 to October 31, already exceeded the 1922 figure, and were 2,285,464. Exports are mostly to the United States of America. A small amount of copra, chiefly sun-dried, is exported, together with a little oil. Most of the oil is obtained by boiling the copra in open coppers, and the yields are not as good as they might be.

Exports of copra and coconut oil were as follows:

	Copra (*Tons*).	*Coconut Oil* (*Gallons*).
1921	103	29,400
1922	331	—

FALKLAND ISLANDS AND SOUTH GEORGIA

These islands are chiefly interested in the southern whaling industry, of which details have been given in Part I. (see p. 106). Sheep-farming is of importance in the Falkland Islands, and tallow is produced and exported. The exports of tallow averaged about 525,000 pounds in 1919 and 1920, but dropped to about 118,000 pounds, valued at £909, in 1921.

AUSTRALASIA

COMMONWEALTH OF AUSTRALIA

The Australian Commonwealth includes the island of Tasmania, and comprises an area of approximately 2,974,581 square miles. About five-thirteenths of the area is situated in the tropical zone, and the Commonwealth of Australia makes up nearly one-quarter of the whole British Empire. Nevertheless, it is one of the most sparsely populated countries of the world, the number of inhabitants per acre being only 1·87, and the total population in 1921, 5,510,229. On the coast the rainfall is often abundant, but in large tracts of the interior it is very limited, and the atmosphere dry.

One of the most important industries of Australia is the raising of cattle and sheep; in 1920 the number of cattle in the Commonwealth were returned at 13,499,737, and the number of sheep was 77,897,555; there is a very large trade in the export of meat and whole carcases, and also in tallow. Australian shipments of tallow amounted in 1922 to 44,744 tons of unrefined tallow, 165 tons of tallow oil, and 1,298 tons of lard. It may be noted that increasing quantities of Australian tallows are finding their way to non-European countries, and particularly to Japan. The exports of tallow in 1923 were expected to be short, and if Japan continues to increase her imports, a somewhat difficult position may result, as total supplies may fall short of demands.

No oilseed crops are found amongst Australia's major crops, but linseed, cotton, sunflower, and ground nuts are all grown to a limited extent.

Linseed.—Flax has been grown intermittently for some twenty years in Victoria, and various attempts to foster the industry have been made, particularly during war-time. However, only about 7,000 acres are under the crop, and the production of seed in 1920-21 was returned at 182 tons. There is no doubt that many parts of the country are suitable for flax-growing, and a grant of £1,000 has been made by the Government for experimental work. At present Victoria is the only State growing flax in any quantity.

Cotton.—This crop was cultivated in Queensland as early as 1860, and some 14,000 acres were planted by 1870, but after the American Civil War cultivation dwindled owing to the reappearance of American cotton on the markets and the difficulties of freightage. In 1913 the Queensland Government made an advance of 1½d. on seed cotton, and ginned it on owners' account; this system of advances was extended, and for the three years ending July 31, 1923, was raised to 5½d. The 1922-23 crop was guaranteed with the State Government, and further guarantees to 1926 have been arranged by the Queensland Government. The interest taken in the crop has been extraordinary, and modern ginning plants have been erected at Rockhampton and Brisbane. An idea of the growth of the industry may be gained from the following figures:

AREA UNDER COTTON.

1920–21	166 acres.
1921–22	7,000 „
1922–23	40,000 „

Still greater extension is expected.

Figures for the production of cotton seed are not available, but cotton oil appears among the exports for 1921-22, although only as 13 tons. Exports of seed may, however, be expected in the near future.

Ground nuts and *sunflower* are only grown on a very small scale, and the latest figures are: ground nut, 1919-20, 155 acres, produced 58 tons of seed; sunflower, 1919-20, 54 acres.

EXPORTS, 1921–22 (TONS).

	Australian Produce.	*Re-Exports*
Hemp, rape, and canary seed	88	—
Copra	—	43,367
Oilcake, including linseed cake	6,849	—
Lard and refined animal fat	1,298	4
Tallow oil	165	—
Tallow oil (unrefined)	44,744	—
Stearine (stearic acid)	878	—
Acaroid resin, grass tree gum, yacca gum	775	—
Oils:		
Castor	7	7
China wood oil	1	8
Coconut (to New Zealand chiefly)	90	—
Fish oil	6	18
Linseed	26	27
Neat's-foot	40	—

The copra comes from many of the outlying islands (see p. 233), such as New Guinea, Gilbert and Ellice, Fiji, Pleasant Islands, and in 1921-22 the bulk of the copra found its way to Germany (17,491 tons), the Netherlands (9,748 tons), and United Kingdom (7,778 tons).

The destinations of the unrefined tallow exports in the same year were:

United Kingdom	19,251 tons.
Hong Kong	1,436 „
Japan	13,084 „
India	1,436 „

Bulletin No. 15, Commonwealth Bureau of Census and Statistics, states that the number of factories dealing with oils and fats in 1920-21 was 92, and 62 of these manufactured soap and candles, while the total value of the output of all the factories was £5,488,388. It will be noted that the exports of stearic acid are considerable, and nearly all of it goes to the United Kingdom.

IMPORTS, 1921–22 (TONS).

Oilseeds:	
Copra ..	46,254
From New Guinea	24,323
,, Pleasant Island	12,191
,, Tonga	2,333
,, Papua	5,032
,, New Hebrides	1,583
,, New Caledonia	151
,, Fiji	146
Coconuts	970
From British Pacific Isles	750
,, Other Pacific Isles	180
Edible nuts, including prepared coconut (chiefly from China and Ceylon)	4,451
Soy for sauces	92
Hemp, rape, and canary seed (chiefly from Japan)	313
Linseed (chiefly from India)	17,799
Oilcake (chiefly from Straits Settlements)	5,632
Oils:	
Castor oil	187
China wood oil	147
Colza oil	397
Linseed oil	2,612
Cotton oil	301
Olive (chiefly from France and Italy)	139
Fish, seal, whale, penguin	1,042
Beeswax (chiefly from the United Kingdom)	99
Carnauba, Japanese, or vegetable wax (chiefly from Brazil and United States)	136
Mastic and sandarac (chiefly from France)	243
Shellac (chiefly from India)	352
Other resins (chiefly from U.S.A. and France)	5,352

Apart from tallow and other animal fats, stearine, linseed cake, and re-exported copra, Australia is not at present a producer of exportable oils, oilseeds, or oil cakes. The import and export figures do not give much indication of the importance of oilseeds and their products in Australia. It is practically impossible to arrive at any accurate idea of the country's requirements, but being largely an agricultural or pastoral country, the demands for edible oils will be comparatively small, and easily met by existing factories in the Commonwealth. Fair quantities of linseed oil are evidently required, and copra is also imported in considerable quantities, though it is not possible to ascertain what proportion is absorbed in Australia by oil factories or re-exported.

Australia is the only source of acaroid resin (see p. 131), and it is certain that exports of this product might be increased considerably. The resin is, however, of comparatively low value, though it seems that the demand in the United Kingdom is on the increase, and it may become more valuable as it becomes better known.

Although fairly large quantities of beeswax are produced in Australia, it

appears that production does not satisfy local demands. In 1920-21, 78,181 pounds* were produced (23,234 pounds in New South Wales, 23,222 pounds in Victoria); 28,235 pounds, valued at £2,452, were imported.

NEW ZEALAND

The only oilseed crop of importance in New Zealand is linseed. Nearly all the linseed is grown in the district of Canterbury, and cultivation has shown a great increase since 1909. In that year only about 400 acres were under the crop, while in 1920-21 the acreage was nearly 10,000. In 1921-22, however, the area is given as only 6,000 acres, and the total yield of seed for that year was estimated at 2,830 tons; in 1922, 912 tons of linseed, valued at £14,924, were exported, almost all to Australia. Very little linseed oil appears to be produced in New Zealand (in 1922 only 95 gallons were exported), and nearly all the country's requirements are imported, chiefly from the United Kingdom.

New Zealand is very largely a pastoral country, and supports large numbers of sheep. As would be expected, the exports of tallow are an important source of revenue, and in 1922 these were valued at £750,574. Most of this tallow is exported as "unrefined," and New Zealand's chief customer is the United Kingdom.

The whaling industry of New Zealand has declined in importance; the remaining centres are at North Auckland and Marlborough, and details as to exports will be found in Part I., p. 107.

Turning to the imports, it is noticeable that only small quantities of oilseeds are imported, but comparatively large amounts of oil, and practically no crushing or extraction of seed is carried on in the country.

IMPORTS IN 1922 (TONS).

Copra	52
Desiccated coconut (from Ceylon)	332
Cocoa butter (chiefly from the United Kingdom)	481
Cod-liver oil	57
Fish oil	74
Castor oil (from India)	158
Coconut oil (chiefly from Australia and Fiji)	186
Colza oil (chiefly from U.S.A.)	164
Linseed oil (chiefly from the United Kingdom)	1,225
Olive oil (chiefly from Austria and Italy)	55
Shellac	27
Turpentine (chiefly from U.S.A.)	259
Beeswax	21
Stearine	179

OIL EXPORTS IN 1922.

Tallow, refined (valued at £92,543)	2,787 tons.
Tallow, unrefined (valued at £658,031)	23,708 „
Linseed	20,429 centals.
Whale oil	92 tons.
Stearine	25 „

* *Official Year Book Commonwealth of Australia.*

The demand for oils in New Zealand is thus, in most cases, small, the largest being that for linseed oil, which is rather curious in view of the export of linseed from New Zealand. Imports of linseed oil are certainly not very large, but if the demand is regular and likely to increase, the production in New Zealand of oil from home-grown seed should be worth consideration.

New Zealand is of considerable importance as the producer of kauri "gum" or copal, the annual exports of which, for a period of ten years prior to 1921, amounted to 5,386 tons, valued at £340,257, equivalent to an average price of £63 per ton.* The kauri copal exports are practically all shipped from Auckland. Exports in recent years are as follows:

	1920–21 (*Tons*).	1921–22 (*Tons*).
To United Kingdom ..	3,224	1,824
,, United States of America	2,544	4,191
,, Canada	314	129
,, Australia	49	84
,, Germany	—	95
,, Netherlands	—	45
,, Other countries	—	23
Total (tons)	6,131	6,391
Value (£)	524,701	563,270

A noticeable feature of the exports is that shipments to the United States of America appear to be increasing at the expense of shipments to the United Kingdom. The demand for varnish resins and other paint materials in the United States is extremely large, and it seems inevitable that such products as kauri resin should be shipped direct to the States from New Zealand rather than through the United Kingdom.

FIJI ISLANDS

The coconut palm represents one of the chief sources of wealth of these islands. Cultivation is carried on in all the islands except Vitilevu (where a moth pest prevents the trees from fruiting), and the industry is capable of expansion. In 1921 the area under coconut was estimated at 51,361 acres. As a rule, cattle are grazed between the coconut trees, but the scarcity of labour has a bad effect on cultivation of plantations. Except in the case of the fruit used for local consumption, the majority of nuts are converted into copra, but owing to the dampness of the climate sun-drying is not very successful, and experiments with artificial drying have recently been made. A mill was being erected at Suva in 1920 for the production of coconut oil, and in 1922 exports of oil exceeded 130 tons.

Cotton was formerly grown in Fiji, the maximum area since 1900 being in 1914, with 530 acres. The industry dwindled, but there is some indication of its revival.

* *Bull. Impl. Inst.*, 1922, **20**, 335.

EXPORTS FOR 1922 (TONS).

Coconuts (mostly to Australia)	879,250
Copra (of which 13,047 tons went to Germany and 6,568 tons to United Kingdom)	21,987
Coconut oil (mostly to New Zealand)	134

The copra exports in 1922 were valued at £346,096.

IMPORTS FOR 1922 (TONS).

Ghee (chiefly from India)	102
Edible oils	230
Resin	41
Grease and tallow	171
Linseed oil	43
Rape and mustard seed	238

PACIFIC ISLANDS

The various British groups of islands not dealt with already are chiefly of interest as producers of copra, and some are of considerable importance, as the following data for exports from various sources in recent years will show:

COPRA EXPORTS.

	Year.	*Tons.*
Gilbert and Ellice Islands	1919	5,000
New Hebrides	1921	5,268
Tonga	1919	21,574
Solomon Islands	1921-22	12,109
New Guinea	1922	25,894
Papau	1921	2,984

Cotton is also grown in the New Hebrides; 1,539 and 690 tons of seed were produced in 1920 and 1921 respectively. It is of interest to note that an important British firm has large coconut plantations in the Solomon Islands.

The total area under coconuts in New Guinea in 1921-22 was over 194,200 acres, but only about 78,000 acres were in bearing.

In 1920 there were about 46,000 acres under coconuts in Papua, of which about 4,100 were in bearing. Cotton was formerly grown, but has become of no importance in recent years.

PART III

THE DEVELOPMENT OF IMPERIAL RESOURCES OF OILSEEDS AND OILS

General Considerations.

In considering the possibilities of exploiting existing cultivated crops or areas of wild oilseeds, or of creating fresh sources of supplies by planting in new fields, one is immediately faced with a variety of problems influenced by factors the importance of which is generally only grasped by those who have had long and intimate contact with such problems. To take a simple instance, one might cite that of growing castor seed for export in a region where the plant had not been grown previously on an appreciable scale, but where it was known to flourish.

One of the first questions that would arise would be, What is the best variety to grow ? Now, many varieties of the castor plant are known, yielding seed of very varying size, and also differing somewhat in other characters, such as cultural requirements and ease of collection of seeds.

For the sake of simplicity we will assume that in this particular case the yields of seed per acre for the small-seeded varieties do not differ appreciably from those obtained with the large-seeded variety, and that the price obtainable per ton of seed is in each case the same. The final question then is, Will it pay best to export large or small seed ? The answer is simple, *Small seed*, the reason being that the storage and cargo space occupied by the small seed is much less than for the large seed.

This is an important consideration at all times, as small seed means less bags per ton of seed, less space for storage before, during, and after export, and lower freight charges. This question of " bulk per ton " was of particular importance during the War, when shipping was restricted, and obviously it will always be an important factor.

To take another example illustrative of the " bulk per ton " question, comparison between copra and palm kernels is of interest. Copra and palm kernels yield oils of very similar—but not identical—properties, copra (coconut) oil being the more valuable; palm kernels, however, occupy much less space per unit of weight than copra, and are more easy to handle (*e.g.*, kernels can be unloaded from bulk in ship's hold by suction plant, such as is used for grain), and in consequence palm kernels are in some cases being worked in preference to copra, though the latter is more valuable.

In considering the possibilities of utilizing areas of wild trees or plants bearing oilseeds, several most important factors have to be considered, one of

the most important being ease of collection, a question intimately connected with transport facility, and depending on the possibility of obtaining sufficient cheap labour *at the time when it is wanted* for the harvest. Such questions can obviously be answered only after a careful study of local conditions.

The difficulty of obtaining labour for collection is well illustrated by the case of Para rubber seed, of which large quantities are available, but the collection of which is laborious and expensive, though in this case one is considering a by-product of trees cultivated for rubber, and not wild trees. Another point to be borne in mind is the fact that wild trees and plants often give widely varying yields of fruit from year to year, owing to climatic and other causes.

The collection of the seed is not the only problem in many cases; added to this is frequently the necessity of shelling the nuts and drying the kernels, so that freight may be saved and the kernels prevented from deterioration during transport. This problem of shelling nuts is one of great importance, and undoubtedly has prevented the successful exploitation of extensive areas of certain wild oilseeds. Perhaps the most obvious examples are afforded by cohune nuts—abundant in parts of Central America, such as British Honduras—and babassu nuts—abundant in South America. In both cases these nuts have extremely hard, thick shells, and although small quantities of both cohune kernels and babassu kernels have appeared on the oilseed markets for some years past, the difficulty of shelling the nuts either by hand or by special machines has prevented rapid or large developments.

In connection with machinery for shelling nuts, it must be borne in mind that such machines have generally to be lightly constructed or so made that they can be easily taken to pieces to facilitate transportation from place to place—often under very difficult conditions—and, further, that simplicity of construction, ease of repair, and the power to withstand rough usage by unskilled labour are all more or less essential features of machines for use in the tropics.

Another most interesting but complicated problem, connected with countries which have a large exportable surplus of oilseeds, is that of deciding whether the seeds should be exported as such, or worked up locally, and either the oil alone or both the oil and cake exported.

There are many aspects of the problem, and, as is usual in such problems, each particular case must be taken on its merits. A comparatively simple problem is afforded where there is little or no local demand for oil and oilcake, or no large market near at hand; here exportation of seed is obviously likely to prove best. If a local oil-crushing industry is to be established it is desirable that modern and efficient machinery should be used, as the crude native mills and presses are inefficient, and generally produce oil and cake comparing unfavourably in quality and value with those manufactured by machinery.

The establishment of an oil mill entails considerable initial expenditure, and also necessitates skilled supervision; further, the oil mill must be certain of obtaining raw material in sufficient quantity to enable it to be run regularly throughout the year, as intermittent working would be most uneconomical.

One of the chief difficulties which manufacturers of oil for export all over the world have to face is that of containers for the oil. The most-used con-

tainers for all oils are the ordinary wooden barrels or casks. Under perfect conditions of storage and transport but little fault can be found with the wooden barrel; unfortunately, conditions during storage and shipment seldom are perfect, and the leakage of oil (caused by opening of the staves owing to shrinkage in dry atmospheres and to pressure when the barrels are piled—*e.g.*, in ship's hold) is a serious drawback. The steel drum or barrel certainly avoids the above-mentioned difficulty, but labours under the disadvantage that when empty it cannot be taken to pieces like the wooden barrel, and stowed in a small space for return to be refilled. Attempts have been made to produce steel barrels in two halves, which would fit together one inside the other when empty; but the problem of devising an oil-tight packing or joint is not an easy one, and barrels of this type do not appear to have been used for oil transport to any considerable extent up to the present.

The transport of crude vegetable oils in bulk in ship's tanks avoids the difficulty and expense of barrels, and large quantities of some oils are shipped in this way—*e.g.*, crude soya-bean oil from Japan and the East; contamination of the oil with sea-water, etc., is, however, a not uncommon occurrence, while the necessity of cleaning out the tanks thoroughly before a return cargo of a different nature can be carried is another obvious difficulty.

Where highly refined oils, such as edible oils, are to be carried, the utmost care must be taken in the selection of barrels. Generally new barrels (or at least barrels which have only been used previously for high-grade edible oil) must be employed. These barrels must be cleaned with the utmost care, and generally the inside of the barrel is treated so as to render it oil-proof and to prevent splinters of wood becoming detached. Sodium silicate is largely used for this purpose, and even in some cases cellulose varnishes.

Generally speaking, one might say that the production and transport of edible refined oils entails so many difficulties that the manufacture of such oils in the tropics for export to Europe would not be likely to succeed.

Perhaps the strongest reason for advocating the expansion of oil and cake manufacture in the country of production of the seed is that grounded on one of the most important of the first principles of agriculture—viz., the need for avoiding impoverishment of the soil.

In such countries as India, where oilseeds are grown in enormous quantities and exported either in the form of seed or as oil and oilcake, the gradual impoverishment of the soil caused by removal of the seed *without return of* the non-fatty matter to the soil—either by using cake itself as a fertilizer, or the manure of animals fed on the cake—is a most serious matter, which has for long exercised the minds of agriculturists and others.

At first sight the obvious remedy in such a case is to establish oil mills in the country, the oil alone being exported and the cake reserved for local use, if necessary applying an export tax on oilseed and oilcake as a further safeguard. This question, however, is often further complicated by the existence in the countries of importation of decidedly heavy protective import duties on oils compared with a small duty or no duty at all on oilseeds.

The whole problem is one which bristles with difficulties from the agricultural, legislative, and commercial standpoints, and can only be solved after the most careful consideration of all the many conflicting interests involved. The matter is *sub judice* at the present time in one of the world's most important oilseed growing countries, and it is not proposed to discuss this problem further here, although it is one of the greatest importance.

The above brief mention of this matter has been made merely to indicate a few of the factors likely to be involved in attempting to work oilseeds on the spot in preference to exporting them to Europe or other countries where oil mills have for long been established, and where skilled labour and good markets for the products are available.

In connection with this problem it might be of interest to note that oil mills were established some years ago in the Philippine Islands to work copra produced there. In recent years coconut oil production does not appear to have been very successful until the enforcing in 1921 of a protective tariff in the United States of 20 cents a gallon on coconut oil not produced in American possessions. During the War coconut oil mills were established in the Dutch East Indies, and exports of oil rose to over 68,500 tons in 1919, but dropped to only 10 tons in 1922, showing that under present conditions the production of coconut oil in the Dutch East Indies cannot compete with exportation of copra.

The question of the commercial exploitation of new or little-known oilseeds is one which necessitates the most careful consideration of a variety of factors, and is, moreover, a question which can only be decided by those who have an intimate knowledge of technology and commerce.

A new oilseed must be capable of being placed on the market in good condition, and in fair and regular quantities. Small and irregular consignments cannot be expected to fetch their full price, and may even be difficult to sell at all, as oil manufacturers cannot afford to modify machinery and methods of operating to suit small and irregular supplies.

In any case, a new oilseed will have to compete with the usual commercial oilseeds, and its value will depend not only on its oil content and the character of the oil, but also on the value of the non-fatty residue; the value of the latter as a feeding-stuff depends on its content of nutrient constituents (see p. 40), such as protein and carbohydrates, and of indigestible fibre, and also on its freedom from unpalatable or definitely harmful substances. The suitability of the residue for feeding purposes can only be definitely decided by comprehensive feeding trials with animals. Where the residue cannot be used as a feeding-stuff for animals it can only be used as a manure, for which purpose it will naturally sell at a much lower price than if it could be used for feeding.

It is a common occurrence to meet with references to " new " oilseeds in the technical and scientific journals. After many years of experience the authors venture to suggest that it is very seldom that such " new " seeds ever attain commercial importance. Without wishing in any way to be pessimistic, one must confess that there is often more enthusiasm than common sense exhibited by investigators of new seeds, and that a little more consideration of practical

details would generally save a great deal of unnecessary work, and even loss of money.

The two following examples of "new" oilseeds will serve to illustrate the point; the examples may be thought to be glaring examples, but are, as a matter of fact, quite typical.

Some years ago one of the authors had occasion to examine a certain West African "seed" not previously examined or identified, and found it to contain a high percentage of oil of an excellent character; further supplies of the "seed," together with botanical specimens, were asked for, and when examined these at once showed the impossibility of commercial exploitation. The "seed" originally sent were kernels which in their natural state were enclosed in an intensely hard, thick shell, and the only method of removing the shells without damaging the kernels hopelessly was by carefully sawing through the shell.

In the other case a great deal of interest was aroused in another West African seed, which was investigated and found to contain a hard fat very suitable for edible purposes. At the time much was written about the potential value of this oilseed and its products, and all kinds of hopeful forecasts were made. It was later found that the seed was borne by a large, and slow-growing, forest tree which was not abundant (though widely distributed), and that the demand for the seed for use as a native food-stuff would prevent entirely its exploitation as an oil-seed. It is curious to note that one still meets with articles in the technical press relating to this seed, though it was conclusively proved many years ago that the seed was not ikely ever to appear in commerce, and one might add that it never has done so.

To summarize the question of "new" oilseeds briefly, a "new" oilseed must (1) be plentiful, or be capable of easy and cheap cultivation; (2) be easy to collect and prepare for export; (3) not deteriorate rapidly during storage or transport; (4) contain a fair percentage of oil of commercial value, and should yield a non-fatty residue (cake) suitable for use as a feeding-stuff.

In any case, the value of an oilseed will depend on the values of the oil and of the residue *in comparison with known commercial oils and oilcakes*, questions which can only be answered by the chemist and technologist, while the questions of collection and exploitation of the seed in country of its growth entail—at least—an intimate knowledge of local conditions. In attempting to ascertain the value of an unknown or little-known oilseed, one cannot emphasize too strongly the necessity of obtaining for examination large samples of the whole seed or fruit (not the kernels alone), of botanical specimens to enable the tree to be identified, and of supplying to the person to whom the samples are submitted for examination any information relating to the tree (such as local uses of the seed, locality of growth, soil, etc.).

The Future Development of Oilseeds and Oils already of Commercial Value.

This is a question which it is by no means easy to discuss, and it is only proposed to attempt to deal here with some of the more obvious possibilities.

Linseed.

Within the Empire India is the chief producer, followed by Canada. India's exports of linseed go to many destinations, but chiefly to the United Kingdom; Canada's exports now go wholly to the United States of America, where the demand for drying oils is on an enormous scale, owing to such factors as the demands for paint for wooden buildings and in the huge motor industry. India could no doubt increase her crops of linseed, but has to compete with Argentina, where much British capital is invested.

It seems reasonable to suppose that India may in the future become a producer of oils on an increasing scale.

Linseed is grown to some extent in other parts of the Empire, such as New Zealand, Australia, and South Africa and East Africa (in the latter case for fibre). In Australia and New Zealand, at any rate, cultivation might be increased, as Australia imports fair quantities of seed and oil, the demand for which will be satisfied by local production; the production in Australia of seed for export to Europe seems unlikely, owing to the comparatively high costs of labour in Australia and of transport to Europe.

China Wood Oil.

The introduction of the tree producing China wood oil into various parts of the Empire is a question which ought to receive careful attention. At present the demand for China wood oil exceeds the supply, and seems certain to do so for years to come. The demand in America is so good that the tree has been introduced successfully in the Southern United States, while the demand for this oil in the United Kingdom is also increasing.

It does not seem that the exports from China can be largely or rapidly increased, and it is therefore advisable that attempts should be made without delay to grow the tree on a fair scale in any suitable parts of the Empire.

Perilla Oil.

This oil, though largely used in Japan, has never assumed any appreciable importance in Europe. There seems to be no doubt that it might well be used to a large extent in paint and varnish manufacture. So far, experiments in various parts of the Empire do not seem to have led to any definite results, and it is desirable that the possibilities of cultivation should be thoroughly investigated. At present linseed oil is the staple drying oil, but China wood oil has increased enormously in importance in recent years, and other drying oils, such as Perilla oil, might well be added to the list of commercial drying oils.

Rape Seed.

Within the Empire India is the only source of commercial supplies, and in view of the fact that India seems well able to supply the demands for this seed and the growing preference for other oils, it seems unlikely that cultivation elsewhere is worth while.

Cotton Seed.

Cotton seed is perhaps more rightly regarded as a by-product of the cotton industry than as an oilseed *per se*, though it is of immense importance in modern oil and cake manufacture. Cotton growing is on the increase in the British Empire, and supplies of seed are likely to increase. Their exportation in some countries—*e.g.*, Uganda—is more a question of transport than of production, owing to the cheapness and rather bulky nature of the seed. Oil manufacture on the spot may in some cases be the solution of the difficulty.

Soya Beans.

At present the world's exportable supplies of soya beans are drawn entirely from the far East—*e.g.*, Manchuria, China, and Japan—although numerous experiments have been made in growing soya beans in various parts of the Empire, and the soya bean is largely grown in the United States of America. In the latter country the cultivation of the soya bean as a fodder plant is far more extensive than as an oilseed crop.

The growing of soya beans as a seed crop within the Empire seems to depend on several factors, the chief of which is whether cultivation can compete in any particular country with China. Generally, one is inclined to think that the answer is in the negative, though if a good local demand for seed for human food existed cultivation should pay. As a fodder crop or as a green manure, soya beans might well be cultivated far more extensively than at present.

Sunflower Seed.

One may almost say the sunflower will grow anywhere, and it is curious that outside Russia the sunflower as a commercial crop has so far attained but little importance. In recent years India has taken an increasing interest in sunflower seed production; Rhodesia also has produced seed, and other parts of the Empire have grown seed in small quantities. It seems that sunflower seed should increase in importance in various parts of the Empire in the future.

Olives and Olive Oil.

Comparatively little interest has been taken in olive culture within the Empire, though in South Africa cultivation appears to be progressing. In Australia olive growing does not seem to have found favour, and in Northern India interest has only commenced. It seems evident that more might well be done, as the introduction of olives into California has been successful. There must be many parts of the Empire suitable for olives, while the demand for olives and olive oil is large, and likely to continue.

Sesame Seed.

India, again, is a large producer, and should be able to increase production, though it seems unlikely, in view of freight charges, that she could divert her exports to the United Kingdom instead of France and the Continent.

The production in British African Colonies of sesame seed for export might well be encouraged.

Ground Nuts.

Within the Empire, India and Burma, the Gambia, and Nigeria produce enormous quantities of ground nuts. Indian ground nuts are of comparatively low grade, being decorticated to save freight. Considering the demands for ground-nut oil in India and neighbouring countries, the crushing of ground nuts in India on a far larger scale than at present would seem to be worth consideration, as it has been successful in Burma, and the export of Indian ground-nut oil to Europe should be possible in view of China's large exports of oil.

Ground-nut production in the Gambia is large, but the exports have been fairly constant in recent years, and it is not certain if exports could be increased, though the demand for good quality nuts, such as are exported from the Gambia, is enormous, and likely to increase.

The production of ground nuts in Northern Nigeria for export has expanded greatly, and seems likely to continue to expand, though the long rail journey to the coast ports necessitates the shipment of decorticated nuts, which are not of such high quality as nuts in the shell.

Every effort should be made to keep up the quality of Nigerian exports, and it is to be hoped that increasing quantities of the nuts will be worked in England, where the oil might well be used to a greater extent than it now is.

Castor Seed.

It is difficult to ascertain what the demand for castor seed will be in the future. During the War the demand for castor oil was abnormally large, chiefly owing to its use for lubrication, but how far this will be a factor in the future it is impossible to foresee. Commercial supplies of seed are now practically all derived from India and Brazil, but the castor plant is widely distributed, and even if India failed to satisfy increased demands for seed—a most unlikely event—other parts of the Empire could readily do so.

Copra and Coconut Oil.

Although the cultivation of coconuts in British tropical possessions is very large, it seems safe to assume that increased production can be absorbed in view of the enormous demands for copra and coconut oil in Europe and America.

In the main centres of production, such as Malaya and Ceylon, there is little to comment upon. The plantations are mostly run on modern and efficient lines. Pests and diseases are carefully investigated and controlled, and copra and oil of good quality are made.

There is, however, room for expansion of coconut cultivation in the various British African Colonies, and for improvement in quality of copra produced in African Colonies and in various parts of the Empire outside Ceylon and Malaya.

In the production of oil for edible purposes a high grade of copra is desirable, if not essential, and the employment of efficient methods of preparing and drying copra are certainly worth while wherever possible.

Palm Oil and Palm Kernels.

West Africa is the natural habitat of the oil palm, and British West Africa is of enormous importance as a source of palm oil and palm kernels. Until recently the whole of the world's demands for oil-palm products have been met by West Africa, but the oil-palm industry has now spread to the Dutch East Indies and Malaya, with every prospect of a rapidly increasing importance.

Some authorities are even inclined to believe that oil-palm cultivation in the East is likely to prove more renumerative than coconut cultivation, and that the oil palm is less susceptible to diseases and pests.

The possibilities of increasing the output of kernels and palm oil in British West Africa is one which is receiving the careful attention of the Governments and others concerned.

Obviously, the native methods of preparing palm oil in a good many districts are inefficient, both the yield and quality of the oil being poor. Every possible effort should be made to encourage the production of high-grade oil by the natives. A good deal could probably be done also to improve the yield of palm oil by introducing simple presses, such as the wooden presses used in China and Japan, which deal successfully with far more difficult materials.

The possibilities of running the oil-palm industry in West Africa on plantation lines and of manufacturing palm oil by machinery have been much discussed. As far as can be ascertained, no such developments have taken place up to the present in British West Africa, though factories are in operation in non-British countries.

At present the oil-palm industry of British West Africa is worked entirely by the natives, who gather the fruit, prepare the palm oil, shell the nuts, and market the produce on a small scale.

If large plantations are to be formed, or large natural areas of oil palms worked, and factories are to be operated for the production of palm oil and kernels, the effect on native life will obviously be a profound one. Stated briefly, it would result largely in limiting the native to the tending of the trees and collection of fruit.

The problem in British West Africa is, in the main, a question of policy. British manufacturers are ready to undertake exploitation, and the technical side of the question does not offer more than ordinary difficulties, but the difficulties of arranging for concessions without interference with native rights and customs are obviously very great, and so far have prevented exploitation.

Any criticism of the wisdom of this policy does not, we feel, fall within either the scope of the present work or within our powers; in fact, we might say that criticism anywhere is at present undesirable, as the question of the possible influence of oil-palm cultivation in the East (*e.g.*, in Sumatra) upon the West African oil-palm industry is at the moment more or less *sub judice.**

In conclusion, the prospects of the oil-palm industry seem excellent, as the demand for both oil and kernels is enormous and certain to increase.

* See p. xv.

Shea Kernels.

Up to the present shea kernels have not attained any very important position in West African trade, but their popularity as a source of oil for the manufacture of edible fats and for other purposes in Europe is likely to increase. Efforts might be made to increase exports of kernels from Nigeria. The exploitation of shea kernels in the Northern Territories of the Gold Coast evidently offers considerable opportunities, but development is largely dependent on means of transport. It should be possible to induce English oil manufacturers and refiners to deal with shea kernels and oil in greater quantities than at present.

Whale Oil and Fish Oils.

Although the world's chief whaling centre—South Georgia—is within the Empire, the industry is largely in the hands of non-British firms, and the labour employed is also non-British; it is obviously desirable that the Empire's interests in this industry should increase. The production of fish oil and fish manure on a larger scale within the Empire is undoubtedly worth consideration, especially as the demand for fertilizers of all kinds is so large.

LESS-KNOWN MATERIALS WHICH MIGHT BE DEVELOPED.

It would be quite impossible to refer to all the numerous oilseeds and oils of minor or local importance, and it is not easy even to divide such materials into very definite groups indicating their relative importance or possible importance in commerce, but the following might be mentioned as examples of oilseeds and oils which have been exported from the countries of production to Europe:

Kapok seed from Java and the East.
Dhupa seed from India.
Tea-seed oil from China.
Mafoureira nuts from East Africa.
Curcas nuts from West Africa.
Cohune kernels from Central America.
Babassu and other palm nuts from South America.
Candle-nut oil from the Philippine Islands.
Para rubber-seed oil from Ceylon and Malaya.

Kapok Seed.

The kapok tree, *Eriodendron anfractuosum*, is a large tree bearing pods filled with soft, silky fibre or floss surrounding the seed. The tree is grown for the sake of the fibre, which is used for upholstery and in lifebelts, the seeds being a by-product. Large quantities of seed are available in Java, where cultivation is extensive. The seed is of about the same value as cotton seed, and yields an oil of almost identical character. The tree grows in many parts of the tropics, and a closely allied species, *Bombax malabaricun*, is indigenous to Southern India.

Dhupa Seed.

These are derived from a tree—*Vateria indica*—indigenous to the East Indies, and used on the Malabar coast for the production of an edible fat known as "Malabar" or "Piney" tallow. The kernels, which contain up to 49 per cent. of a fat rather stiffer in consistency than lard, have appeared from time to time recently on the English market, and should be readily saleable in quantity.

Tea-Seed Oil.

This oil is produced in considerable quantities in China from the seeds of *Thea sinensis*, and has been exported to Europe in fairly large quantities. The oil is very similar to olive oil in character, and readily saleable for edible purposes. Indian tea seed is produced by a different species, *Thea assamica;* the oil content of this species is low, though the oil is of similar character to Chinese tea seed oil.

Mafoureira or Mafura Seed.

The mafoureira tree, *Trichilia emetica*, is indigenous to South-Eastern Africa, and the kernels have been exported in some quantity from time to time—*e.g.*, from Portuguese East Africa. The seeds yield a fairly hard fat, which is, however, generally rather dark in colour, and of rather high free fatty acid content. Supplies of seed were formerly sent to France, and have recently gone to South Africa, but have never been used to any extent in the United Kingdom. The tree appears to be plentiful in Nyasaland, and might well be exploited.

Jatropha Curcas.

The curcas or purging nut, *Jatropha Curcas*, belongs to the same natural order as the castor seed (*Euphorbiaceæ*). The tree grows in many tropical countries—*e.g.*, British West Africa. The seeds are, or have been, exported from Portuguese West Africa to Portugal in some quantity. The seeds yield a liquid oil which differs in chemical nature from castor oil. In the United Kingdom there does not seem much likelihood of creating a demand for the oil or seed, though if large quantities of seed were available a demand might be created.

Cohune Kernels.

The cohune palm,* *Attalea cohune*, is abundant in Central America, particularly in British Honduras; and there is no doubt that large quantities of kernels might be obtained from this and similar palm trees. The nuts, however, have extremely hard, thick shells, and the problem of shelling is a difficult one. Numerous machines have been devised, and much interest has from time to time been taken in the possibility of exploiting the cohune palm, but the fact remains that no appreciable trade in cohune kernels has resulted as far as the

* *Bull. Impl. Inst.*, 1914, **12**, 237.

authors are aware. Whether this is due to inefficiency of machinery or to other factors, such as labour and transport difficulties, is not clear.

Cohune kernels yield an oil of the coconut-palm kernel type, and would sell readily at prices similar to those of copra or palm kernels.

Babassu and Other Palm Nuts.

The babassu palm, *Attalea funifera*, bears nuts similar to cohune nuts, and is to some extent exploited commercially, the nuts being largely shelled by hand. Commercial supplies have come to Europe in recent years from Brazil.

The gru-gru palm, *Acrocomia sclerocarpa*, which occurs in Grenada and other West Indian islands, yields kernels with an oil of the coconut-palm kernel type. The nuts are comparatively easy to shell—no worse than African palm kernels—but do not seem to have ever been exploited commercially in British Colonies, though supplies of kernels from South America have appeared in Europe.

Several other species of palm in South and Central America bear seeds with kernels which are rich in oil, but have not been exploited up to the present. Generally speaking, the nuts are—like cohune and babassu nuts—difficult to shell.

Candle Nuts.

The candle-nut tree (*Aleurites moluccana*) belongs to the same genus as the China wood oil tree (see p. 47), and is known to be widely distributed in the tropics. It is known, for instance, in Ceylon and Malaya, and in various South Sea islands—*e.g.*, the Cook Islands. In recent years the exploitation of candle nuts as a source of oil has become of considerable importance in the Philippine Islands, and large quantities of oil are exported thence to the United States of America.

So far as the authors are aware, no serious attempt has been made to exploit candle nuts in any part of the British Empire, but attempts might well be made to do so.

The nuts are somewhat difficult to decorticate, but would require decortication on the spot to save freight, while it would be even better to manufacture oil for export—provided oil of good quality were made—as the residue is of little value.

Para Rubber Seed.

The great expansion of cultivation of the Para rubber tree (*Hevea brasiliensis*) in the East (particularly in Ceylon and Malaya) drew attention over twenty years ago to the possibility of utilizing the seeds,* and a considerable amount of work has since been done on Para rubber seed and its products.†

The possibility of exploiting Para rubber seed depends, however, almost entirely on the cost of collection of the seed on the rubber plantations. The

* *Bull. Impl. Inst.*, 1903, **1**, 156.

† A comprehensive article on the possibilities of Para rubber seed and products is to be found in the *Bulletin of the Imperial Institute*, 1919, **17**, 543.

seeds are light and bulky, and are scattered on the ground under the trees; collection of seed is therefore troublesome and costly on the rubber plantations (where labour is often somewhat costly and scanty); further, the seeds must be shelled and the kernels dried thoroughly in order to prevent rapid deterioration (due to the active fat-splitting enzyme present in the kernels), if the kernels are to be stored or shipped, or else the seed must be worked up for oil and cake on the spot as soon as possible. The whole seeds contain about 20 per cent. of oil; the air-dried kernels about 45 per cent.

It is evident that (1) enormous quantities of seed are available on the rubber plantations; (2) the dried kernels, *if shipped in good condition*, should sell readily in Europe; (3) the oil can be used as a drying oil, and though it is inferior to linseed oil in drying power it would sell readily; and (4) the cake has been proved to compare favourably with commercial oilcakes, such as decorticated cotton-seed cake, in feeding value and digestibility.

Up to the present it appears that the cost of collection of the seed has prevented exploitation on any appreciable scale or any regular trade, though small lots of kernels and oil have been sent occasionally to Europe, and attempts have been made to establish small oil mills to work Para rubber seed in the East.

Various Minor Oilseeds.

No attempt can be made to mention even the names of the very numerous oilseeds which are used by natives in various parts of the Empire. Some of these would undoubtedly sell readily in the European markets; a few have appeared sporadically in small quantities, and these and others may, as time goes on, become regular articles of commerce when changes in conditions and increased facilities of transport allow.

The following are merely to be regarded as *notes*, including some of the more likely or promising of these seeds, compiled from such sources of information as the *Imperial Institute Report on Oilseeds, Oils, etc.* (No. 88, Col. Off. Misc. Repts., Cd. 7,260, 1914),* the files of the *Bulletin of the Imperial Institute*,* and very largely from the personal experience of both the present authors over a considerable period of years. The materials may be conveniently grouped roughly under countries, though, of course, many of the tropical products are widely disseminated.

West Africa.

Pentadesma butyracea.† This tree is confined to West Africa, and occurs in Sierra Leone, the Gold Coast, and Southern Nigeria; the kernels are used as a source of fat by the natives. The kernels contain up to 40 per cent. of a moderately hard fat of excellent character, rather similar to shea butter, but the fat content varies very widely in different samples of kernels; as low as 7 per cent. is recorded. The kernels would sell readily if exported in good condition and quantity.

* We have omitted references to particular articles in many cases for the sake of brevity

† *Bull. Impl. Inst.*, 1913, **11**, 569; 1918, **16**, 35.

Mimusops Djave, " Djave " or " N'jave " kernels, Southern Nigeria, and *Dumoria Heckeli*, " Baco " or " Abaku " kernels, Gold Coast, are very similar in character, and yield about 60 per cent. of solid fat similar to, but softer than, shea butter; kernels have occasionally appeared in small quantities on the United Kingdom market, and should be readily saleable in quantity at prices based on those current for shea kernels, with an allowance for the higher fat content.

Lophira alata, " Niam " or " Meni " kernels, Sierra Leone; " Zawa," Sudan; *Lophira procera*, " Kaku " kernels, Gold Coast. The kernels contain 30 to 40 per cent. of pale-coloured fat, which is generally of rather high free fatty acid content, but there seems little doubt that proper collection and drying would produce kernels of good quality. The fat content is only moderately high, and the cake probably unsuitable for feeding purposes. Should be worth about the same price as shea kernels.

Carapa species. Various species of *Carapa* occur in West Africa and in Uganda, and in the tropics generally. The kernels occasionally appear on the markets, but yield a bitter oil which cannot be refined for edible use, nor is the cake fit for feeding. The kernels should sell if put on the market regularly in quantity.

Pentaclethra macrophylla, " Oil " or " Owala " bean, Southern Nigeria; " Fai " bean, Gold Coast. These large, flat, brown seeds yield about 30 per cent. of liquid oil, which should be quite suitable for refining for edible oil. Small consignments have sold in past years in Antwerp, and occasionally in the United Kingdom. The value of the residual cake is uncertain. These beans would only fetch a moderate price, but should sell if shipped regularly.

Ricinodendron africanus, " N'sa sana " seed, Southern Nigeria. These seeds yield an oil very similar to tung oil (see p. 47), and the oil would no doubt sell well as a drying oil for paints, etc. It is practically impossible to shell the nuts, and as these only contain about 30 per cent. of kernel it would be unprofitable to export whole nuts. The whole nuts might be treated in West Africa by grinding and extraction of the oil with solvent, but this would not be worth while unless very large amounts of seed were available.

" Po-Yoak " kernels, Sierra Leone.* These also yield an oil similar to China wood oil. They are produced by a species of *Parinarium*, and it is of interest to note that nuts of *P. Mobola* appeared on the Liverpool market over forty years ago. In view of the demand for oil of the China wood type, these kernels might be utilized if obtainable in quantity.

Polygala butyracea, " Cheyi " seed,† tropical West Africa. The seed yields a soft yellow fat of very distinct character; the seed would sell readily.

" KISIDWE " KERNELS. These are probably derived from *Allanblackia floribunda*. A sample of kernels from the Gold Coast ‡ yielded 72 per cent. of hard fat which should be of value for edible purposes; the residual meal was bitter. No information appears to be available as to possibility of supplies, but the kernels should sell readily.

* *Bull. Impl. Inst.*, 1918, **16**, 38.
† *C.O. Misc. Rept.*, Cd. 7,260, p. 573; *Bull. Impl. Inst.*, 1913, **11**, 62.
‡ *Bull. Impl. Inst.*, 1922, **20**, 463.

"PIASSAVA" OIL.* The fruits of certain species of *Raphia* ("Piassava") yield an orange-coloured oil similar to palm oil; as Raphia palms are plentiful in parts of West Africa, this oil might be exploited.

"N'GORE" KERNELS. Probably derived from *Ongokea Gore*. The kernels contain about 70 per cent. of oil of the castor-oil type, and might be valuable.

Oncoba echinata, "Gorli" seed. The seeds of this plant from Sierra Leone yield a fat containing about 80 per cent. of chaulmoogric acid, the characteristic constituent of Indian "chaulmoogra" oil, which is now proving of great value as a cure for leprosy. "Gorli" seed might become of some importance as an additional source of chaulmoogric acid.

Jatropha curcas. These seeds have been exported to Europe from Portuguese East Africa, and, like many other indigenous oilseeds, would sell if exported regularly in fair quantities to Europe.

Sudan.

Lophira alata (see above, p. 250) occurs in the Sudan, also the shea tree, but no information is available as to their abundance.

"Senat" seed. The seeds of a small species of melon are used as a source of oil, and have been exported from the Sudan (*e.g.*, 3,463 cwts. in 1910); they yield 30 to 40 per cent. of pale-coloured liquid oil similar in character to melon-seed oil, and suitable for edible purposes. Seed should sell readily in quantity. Water-melon seed also contains about 24 per cent. of oil, but the husks are tough, and though the oil is of good character, the seed would probably be of low value.

Salvadora persica seeds† yield 45 per cent. of very hard fat, which would probably be valuable if it could be refined for edible use.

Lettuce seed.‡ The seed of the lettuce plant yields about 44 per cent. of liquid non-drying oil, and this plant has been suggested as suitable for growing in the Sudan as an oilseed crop to supplement sesame seed.

East Africa.

A species of *Carapa*—*C. grandiflora* (see p. 250), the shea tree—and also the oil palm occur in Uganda, but no information has been met with regarding their abundance, and even if available in quantity, exploitation seems at present unlikely in view of transport facilities.

Nyasaland.

"Mafoureira" nuts (*Trichilia emetica*) occur, but so far as we are aware are not exported from Nyasaland as they are from Portuguese East Africa.

South Africa.

Various indigenous oilseeds grow in South Africa, but there is little or no information to indicate whether any of these could be obtained in quantities to allow of export. The following might be mentioned:

* *Bull. Impl. Inst.*, 1918, **16**, 35. † *Ibid.*, 1913, **11**, 56. ‡ *Ibid.*, 1919, **17**, 37.

Calodendron capense, "Cape Chestnut."* The seeds yield oil similar to cotton oil; the residual cake is bitter.

Bauhinia esculenta, "Gemsbok" beans.† The kernels contain about 40 per cent. of liquid oil of similar character to cotton-seed oil.

Pappea capensis.‡ The kernels contain over 70 per cent. of non-drying oil which appears unsuitable for refining for edible use; the residual cake is bitter and contains saponin.

Madia sativa. A plant common in Chile and California, and cultivated in North Africa and Asia Minor; belongs to the same natural order as the sunflower; it has been grown experimentally in Rhodesia.§ The seed contains about 37 per cent. of liquid oil; the residual cake is, however, of low value as the seeds are small and the tough husk cannot be removed, but is included in the cake. The seed might sell at prices similar to those for sunflower or niger seed.

Ximenia americana. This tree is widely distributed in the tropics. It is termed "wild olive" in South Africa.|| The kernels contain about 65 per cent. of oil, but also contain some rubber-like substance which renders the problem of extracting and utilizing the oil difficult.

"MANKETTI "¶ NUTS (*Ricinodendron Rautanenii*) from South-West Africa, and "maroola"** nuts (*Sclerocarya Caffra*) from Natal and the Transvaal, also contain kernels rich in oil, but are unlikely to be of any commercial value, as the nuts are difficult to shell.

Cape berrywax. This "wax"—really a hard fat—has been produced in the Cape Province from berries of species of *Myrica*, and was in the past exported in small quantities. Apparently, preparation is not now renumerative, though there should be no difficulty in selling the wax in Europe.

India.

India is rich in indigenous oilseeds, many of which are used as sources of oil by the native population. The following are a few among the many which might be mentioned:

Myristica sp. The nutmeg—*M. fragrans*—is chiefly of value as a spice, but other species—*e.g.*, *M. malabarica*—occur, the kernels of which are rich in fat; so far it does not appear that any of these have been exploited commercially, the most probable reason being the difficulty of refining the fat.

"KUSUM" (*Schleichera trijuga*). The seeds are the source of "macassar oil," but do not seem to be exploited commercially, possibly because they contain a glucoside producing hydrocyanic (prussic) acid.

Calophyllum species. Several species of *Calophyllum* yield kernels rich in oil—*e.g.*, *C. Inophyllum*,†† "Panang" nuts—the kernels of which contain about 70 per cent. of semi-solid oil. These kernels, if exported in good condition, should be saleable, though the oil is probably unsuitable for edible use, and

* *Bull. Impl. Inst.*, 1922, **20**, 5.
† *Ibid.*, 1921, **19**, 142.
‡ *Ibid.*, 1919, **17**, 95.
§ *Ibid.*, 1915, **13**, 344.
|| *Ibid.*, 1917, **15**, 313.
¶ *Ibid.*, 1917, **15**, 35.
** *Ibid.*, 1920, **18**, 481.
†† *Ibid.*, 1913, **11**, 563.

the cake fit only for use as fertilizer. The oil also produces an intense green or blue colour in contact with iron, which might render its extraction troublesome, though this could probably be obviated.

Mesua ferrea. The kernels of the " iron wood " or " Nahar " tree of Assam contain about 73 per cent. of semi-solid oil suitable at any rate for soap making and other technical purposes, while the residual cake is bitter and reputed to be poisonous.

West Indies.

Acrocomia sclerocarpa, the " gru-gru " palm of the West Indies and South America, yields kernels containing about 55 per cent. of fat similar to palm-kernel oil, but rather softer. Although widely distributed in the West Indies, it does not seem to be sufficiently abundant to allow of any appreciable export of kernels; the kernels are exported from South America at times, and are worth about the same price as palm kernels.

Cohune* and Cokerite† *Palms*. The former (see p. 247) is abundant in British Honduras; the latter (probably *Maximiliana regia*) occurs in British Guiana. The kernels of both are rich in oil, but the nuts are troublesome to shell.

* *Bull. Impl. Inst.*, 1914, **12**, 237. † *Ibid.*, 1916, **14**, 8.

SPECIAL SECTION

By HAROLD MOORE.

LUBRICATING OILS

Vegetable and Animal Oils used for Lubrication.

The importance of vegetable and animal oils for lubrication is now much less than formerly, owing to the introduction and wide application of mineral oils (see below), and it is quite impossible to gain any idea of the amounts of animal and vegetable oils used for lubrication.

The oils chiefly used are castor oil and rape oil; the " blown " or thickened oils are often employed; lard oil and sperm oil are also valued for special purposes; various other oils and fats are often employed blended with mineral oils, while fats such as palm oil are used with soaps in making stiff greases such as railway-wagon grease. The use of certain oils is referred to under the particular oils in Part I.

MINERAL LUBRICATING OILS AND PARAFFIN WAX

Introduction.

Sources of the Products.

Lubricating oils and paraffin wax may be prepared from crude petroleum, shale oil, lignite tar, or coal tar. Of these by far the most important source is petroleum crude oil. The shale oils are somewhat similar to the petroleum derivatives, but lubricants prepared from them are not considered to be of equal quality to the oils obtained from crude petroleum. Though both waxes and lubricants may be obtained from lignite tars by special refining processes, both the quality and the yield are poor, and as a result they are only supplied in a few local markets, particularly in Germany.

The coal tar derivatives, though of importance for other industrial purposes, are very seldom employed as lubricants, and only for the manufacture of some of the cheaper greases. At the present time both lignite and coal tar derivatives are used to such a small extent as lubricants that they may be omitted when considering lubricating oil statistics, and their qualities are such that it is unlikely that they will come into extensive use except in the extreme case of a world petroleum shortage.

Methods of Manufacture of Lubricating Oils.

Lubricating oil prepared from petroleum may consist either of the heavier distillates, which yield the spindle and red and pale oils of varying viscosity, or may be made by the refining of the residue in the still, after the petrol, kerosene,

gas oil, and light lubricant fractions have been removed. The nature of the products obtained, both from the distillate and the residue, is very much dependent upon the type of the crude oil used. Crude oils of the naphthenic and asphaltic types yield high viscosity distillates of comparatively low flash point and high specific gravity, whereas the distillates obtained from crudes of the paraffin type, such as Pennsylvanian crude, are of low specific gravity, low viscosity, and high flash point. As a general rule, oils of the Pennsylvanian type command higher prices on the market than the corresponding oils obtained from asphaltic or naphthenic base crude oils.

The preparation of residual oils, named cylinder stock, has in the past mainly been confined to the Pennsylvanian and mid-Continental fields of the United States, where the nature of the crude oil lends itself to simple and cheap processes of cylinder stock manufacture. The dark cylinder stocks obtained as residue of the distillation, without further treatment, are mainly employed for steam engine cylinder lubrication. During recent years large quantities of this cylinder stock have been treated with decolorizing materials, such as fuller's earth and bauxite in order to remove its dark colour, whereby a product of extremely high viscosity and of an amber colour is obtained. This type of oil is known as filtered cylinder oil, and it is only used to a very small extent in the unblended state, its main use being as a base for blending with distillates, so as to obtain the high viscosity blended oils required for internal combustion engine lubrication.

During recent years the preparation of filtered cylinder stock has been extended to other fields, and it is now being prepared from Western—that is, Texas and Californian—crude oils.

The details of the refining process are exceedingly involved, and are undergoing continual changes as improvements in process are discovered.

The Empire Requirements in Lubricants.

At the present time the Empire is a very large consumer of lubricants, and only produces them to a very small extent. The imports of lubricating oils into the different countries of the British Empire are as follows:

Imports of Lubricating Oils in 1921.

United Kingdom	49,024,668	gallons.
Northern Rhodesia	29,350	,,
Southern Rhodesia	211,279	,,
Union of South Africa	2,484,878	,,
Canada	4,940,282	,,
Newfoundland	147,686	,,
Trinidad and Tobago	130,808	,,
Hong Kong	1,543,806	,,
India	6,899,336	,,
Straits Settlements	1,474,594	,,
Australia	8,472,934	,,
New Zealand	1,634,347	,,
Total	77,003,968	,,

To arrive at the Empire consumption of lubricating oils, against these amounts must be offset the amount of lubricating oils exported, which is as follows:

EXPORTS OF LUBRICATING OILS IN 1921.

United Kingdom	5,479,530 gallons.
Trinidad and Tobago (taken as 1919)	8,501 „
Hong Kong	1,067,255 „
India	966,701 „
Australia	29,108 „
Total	7,551,095 „

As is seen from the tables, the imports of lubricating oil into the United Kingdom for the year 1921 amounted to 49 million gallons, and the total imports for the Empire to 77 million gallons. If the Empire exports of lubricants, which amount to 7½ million gallons, be deducted from this last figure, a remainder of 69½ million gallons represents the Empire's requirements per annum. This, taken at a specific gravity of 0·9, amounts to 279,000 tons. If we consider that this is to be manufactured from petroleum crude oil, and if the average production of lubricating oils on the crude oil be taken at 6 per cent. (a larger yield may be obtained from specially suitable crude oils), there would be required 4,650,000 tons of crude oil as raw material.

Empire Production of Petroleum.

The total Empire production of petroleum (including shale oil) for 1921 amounted to 1,965,759 tons only, or 2,145,491 tons including Egypt, the production of the different countries being as follows:

EMPIRE PRODUCTION OF PETROLEUM, INCLUDING SHALE OIL, IN 1921.

United Kingdom	145,000 long tons.
Canada	26,792 „ „
Trinidad	336,308 „ „
India	1,247,687 „ „
Sarawak	201,572 „ „
Australia (taken as 1920)	8,000 „ „
New Zealand (taken as 1920)	400 „ „
Egypt	179,732 „ „
Total	2,145,491 „ „

The only source of crude petroleum in the United Kingdom at present is the well at Hardstoft in Derbyshire, the total production of which, since it was drilled, has been something over 1,100 tons.

The Canadian production of crude petroleum is of good quality, but the quantity is small, and but small amounts enter the lubricating oil market. The production of Trinidad varies in quality, some of the oil being of high quality, yielding large amounts of petrol and kerosene, and comparatively small yields

of lubricating oil distillates, but a large proportion of the production is obtained in the form of naturally occurring asphalt, and is therefore not available for the production of lubricating oil. The production of India is mainly from the Burma fields, a small proportion coming from Assam, and a little from the Punjab. The quality of the Burma oil is high, but only a very small proportion of it is worked up into lubricating oil. The Sarawak oil fields only date from 1911 as producers, but the production has steadily increased, and the figure for 1922 is slightly over 400,000 tons, the production of 1921, 201,562 tons, being approximately doubled. The oil is of a naphthenic type, but paraffin base oils have been obtained quite recently at the lower levels. The crude is of high quality, though somewhat deficient in light fractions. At the present time comparatively little of it is being used for the preparation of lubricating oils. In Australia and New Zealand there is practically no production of lubricating oils at the present time. The quality of the oil found in Egypt (principally on the coast, near the mouth of the Gulf of Suez) is not such as to give large yields of lubricating oils. A refinery is now in course of erection in Australia by the Anglo-Persian Company for the treatment of Persian oil, and should come into operation in 1924 or 1925.

Supply of Lubricants.

The major portion of the world's requirements of both lubricating oil and paraffin wax is obtained from the United States, which country produced approximately two-thirds of the world's crude petroleum output, and possesses an even greater preponderance in the manufacture of lubricants. The manufacture of lubricants and waxes is only carried on from the better classes of crude oils, and as the oils of the United States are of high average quality, the refiners of that country have gained a preponderating position in the lubricating oil market. The preparation of lubricating oil is one of the higher branches of petroleum refining technique, and is therefore more highly developed in the older fields of the United States than in the newer fields of the British Empire.

Empire Production of Lubricants.

The only indigenous production of lubricating oils in the United Kingdom is that from the Scottish shale industry, and the annual production of lubricating oil from this source is only 2,718,001 gallons (1922). The main lubricating oil obtained from the Scottish shale industry is a spindle oil, which is generally used blended with oils of petroleum origin. It will be seen that though at the present time a considerable amount of raw material is obtained within the British Empire, the production of lubricants is extremely small, and bears a very small ratio to the Empire requirements.

The requirements of the United Kingdom, which, it will be seen, are more than one-half of the total Empire requirements, are at the present time almost entirely supplied by the United States, the only serious competitor of the United States being Russia, from which comparatively small amounts of lubricating

oils are being received at the present time. There is, however, a possibility that the refineries of the Anglo-Persian Company situated in the United Kingdom may in the future produce sufficient lubricating oil to meet a considerable proportion of the requirements for this country. These refineries have only recently been installed, and are now producing petrol, kerosene, and fuel oil, but they may extend their production to lubricating oil at any date. The crude oil employed in these refineries is obtained from Persia, which field is practically entirely under British control. The development of the Persian production may be seen from the following table, showing the world's production, that of the United States, and that of the Persian fields:

PRODUCTION OF CRUDE PETROLEUM (IN U.S. BARRELS OF FORTY-TWO U.S. GALLONS).

	1921.	1922.
Total world's production	765,066,000	854,809,000
United States production	460,639,000	557,531,000
Persian production	14,600,000	21,909,000

The Empire production of crude petroleum, though small, is increasing, and there is no doubt that with its further development, as the average quality of the crude oil is quite high, there will be an increasing tendency towards employing these crude oils in the production of lubricants. In addition to this there are very large oil-shale fields situated throughout the Empire, and as the economic development of the shale industry advances, these fields may be further developed and supply material for lubricant manufacture.

For the near future, however, we shall have to rely almost entirely upon petroleum as a source of lubricants.

PARAFFIN WAX.

There are only certain types of crude petroleum oil which yield paraffin wax to any great extent, and the major portion of the Empire production of crude petroleum is of a type which is deficient in paraffin wax. The oils from Burma and Sarawak are of a naphthenic type, which is not a type which yields a solid paraffin. At the present time practically the whole supply of paraffin wax imported is obtained from the United States.

Method of Manufacture of Paraffin Wax.

Certain types of crude petroleum contain paraffin wax, but its occurrence is mainly confined to the paraffin base type. Oils of purely naphthenic origin are completely free from this substance. Pennsylvanian and mid-Continental oils are comparatively rich in wax. Some of the Texas oils contain wax, whilst others are free from it. When the oil is distilled the paraffin wax is found to be present both in the distillate and in the residue, but if the residue is run to a dark steam refined cylinder stock, the larger portion of the wax passes to the distillate, and the cylinder stock may not require treatment for wax removal. In the better class of filtered cylinder stock the wax is removed prior to the oil being put on

the market. Both in distillates and cylinder stock the removal of wax is brought about by freezing the oil, or in some cases by freezing a mixture of the oil, together with a certain amount of naphtha (employed to facilitate the removal of the wax), which treatment is followed by passing the oil through a filter press, when the wax remains in the press in the form of a cake, or alternatively, instead of a filter press, the wax may be removed by means of a high-speed centrifuge, as in the Sharples process. The latter process gives more complete removal of the wax than the former process, and its use has been largely extended during the last few years. The removal of wax is an economic advantage not only on account of the value of the wax obtained, but on account of the wax-free oil commanding a higher price on the market.

Empire Requirements in Paraffin Wax.

The requirements of the Empire, as shown by the import figures for 1921, are as follows:

IMPORTS OF PARAFFIN WAX IN 1921.

United Kingdom	35,472 long tons.
Union of South Africa	4,143 ,, ,,
Canada	761 ,, ,,
Hong Kong	4,995 ,, ,,
India	64 ,, ,,
Straits Settlements	585 ,, ,,
Australia	2,331 ,, ,,
New Zealand	1,590 ,, ,,
Total	49,941 ,, ,,

Empire Production of Paraffin Wax.

The production of paraffin wax in the Scottish shale industry in 1922 was 16,155 tons, and the production in Canada in 1921 was 4,811 tons. We may assume these productions to be consumed in the countries of origin, thus leaving some 50,000 tons to be imported from foreign countries for the Empire requirements.

A very good yield of paraffin wax is obtained from some shale oils, and any extension of the shale industry is likely to lead to increased supplies of wax.

The production of oil shale in the United Kingdom in 1921 was 1,966,785 tons, and in Australia, 33,357 tons, the production of the United Kingdom being by far more important than that of any other country. Great deposits of oil shale occur in Australia, Canada, South Africa, and New Zealand, and their exploitation may be considerably extended in the near future. The question of working shale oil is largely one of the cost of labour, and the enormous deposits of the United States are for this reason almost untouched. Oil shale deposits, if worked, might be a source of considerably increased Empire production.

Great improvements have been lately introduced in the method of retorting shale, and extensive developments are still taking place in this direction.

PART IV

INSTITUTIONS FROM WHICH INFORMATION MAY BE OBTAINED

The following is a list of institutions from which information is obtainable:

Institutions in the United Kingdom.

Various Parts of the Empire :

The Imperial Institute, South Kensington, London, S.W.
The Royal Colonial Institute, Northumberland Avenue, London, W.C. 2.
The Crown Agents for the Colonies, 4, Millbank, London, S.W. 1.
Federation of British Industries, 39, St. James's Street, London, S.W. 1.
Department of Overseas Trade, 35, Old Queen Street, London, S.W. 1.

Trade in Oils and Oilseeds :

The Incorporated Oilseed Association, Exchange Chambers, London, E.C. 3.
The London Copra Association, 79, Leadenhall Street, London, E.C. 3.
The London Oil and Tallow Trades Association, 84, Leadenhall Street, London, E.C. 3.
The Liverpool United General Produce Association, Ltd., 13 Rumford Street, Liverpool.
The Hull Seed Oil and Cake Association of the Hull Incorporated Chamber of Commerce and Shipping.

India :

Trade Commissioner: H. A. F. Lindsay, Esq., C.B.E., I.C.S., 42, Grosvenor Gardens, London, S.W.

Canada :

High Commissioner: The Hon. Sir G. H. Perley, K.C.M.G., 19, Victoria Street, London, S.W. 1.

Australia :

High Commissioner: The Right Hon. Andrew Fisher, Australia House, Strand, W.C.

New Zealand :

High Commissioner: The Hon. Sir Thomas Mackenzie, K.C.M.G., 413-416, Strand, W.C

Union of South Africa :

Acting High Commissioner: R. A. Blakenberg, Esq., 32, Victoria Street, S.W. 1.

Newfoundland :

Sir E. R. Bowring, 58, Victoria Street, S.W. 1.

New South Wales :

The Hon. Sir Charles Gregory Wade, K.C., Australia House, Strand, W.C.

Victoria :

The Hon. Sir Peter McBride, Melbourne Place, Strand, W.C.

Queensland :

Major Sir Thomas Bilbe Robinson, K.C.M.G., K.B.E., 409-410, Strand, W.C. 2.

South Australia :

Agent-General: The Hon. E. Lucas, 112, Strand, W.C. 2.

Western Australia :

The Hon. James Daniel Connolly, Savoy House, 115, Strand, W.C. 2.

Tasmania :

Agent-General: A. H. Ashbolt, Esq., 24, Queen's Mansion, 56, Victoria Street, S.W. 1.

Malay States Information Agency, 88, Cannon Street, E.C. 4.
British South Africa Company, Rhodesia House, London Wall Buildings, E.C. 2.
Uganda Railway Publicity Office, 57, Haymarket, S.W. 1.
Ceylon Association in London, 6, Laurence Pountney Hill, Cannon Street, E.C. 4.
Straits Settlement Association, 7, East India Avenue, E.C. 3.
West Indian Committee, 15, Seething Lane, E.C. 3.

Institutions in Other Parts of the Empire.

In the various countries themselves information is available from such official institutions as the Agricultural and Forestry Departments and from Chambers of Commerce.

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The following references are merely intended to indicate some of the more useful sources of information on the various subjects, and are not comprehensive. Books or articles in foreign languages are only included when English references are not readily available.

GENERAL.

Statistics, etc.:

Oleaginous Products and Vegetable Oils (International Inst. Agric., Rome, 1923). Area and production of world's principal oilseeds, import and export statistics, with notes on cultivation, exploitation, and progress in all countries.

Review of the Oil and Fat Markets. Published yearly, up to 1922 by Messrs. Thornett and Fehr, since 1922 by Messrs. Faure, Blattman and Co.

Trade Statistics:

The yearly official trade returns should be consulted, such as:
Accounts relating to Sea-Borne Trade and Navigation of British India.

SCIENTIFIC AND TECHNICAL.

The books dealing with the chemistry and technology of oilseeds and oils are very numerous; the following may be mentioned:

General:

Chemical Technology and Analysis of Oils, Fats, and Waxes. By J. Lewkowitsch and G. Warburton. 6th edition. A comprehensive work on the chemistry, analysis, and technology of oils, etc.

Fatty Foods. By E. R. Bolton and C. Revis. Deals concisely with the preparation, uses, technology, and chemical analysis of oils and fats, particularly those employed for food.

Manufacture:

The Production and Technology of Vegetable Oils. By T. W. Chalmers. Construction and operation of oil presses and solvent extraction plant, equipment of oil mills, manufacture of oils and oilcakes, refining of oils.

Hydrogenation :

The Hydrogenation of Oils. By Carleton Ellis. 1919. The theory and technical use of catalysts for hydrogenation, manufacture of hydrogen, properties and uses of hardened oils.

Fats—Natural and Synthetic. By W. W. Myddleton and T. Hedley Barry. 1924. Processes of hydrogenation, and the influence of methods on the composition of the products, and their use in various manufactures.

Lubrication :

Lubrication and Lubricants. By L. Archbutt and R. M. Deeley. 1920. The properties, preparation, uses, and examination of lubricating oils and greases of all kinds, including oils and fats.

Oilcakes and Feeding of Animals :

The Scientific Feeding of Animals. By O. Kellner. English translation by W. Goodwin.

Oilseeds and Feeding Cakes. Imperial Institute Monograph.

Scientific Feeding of Domestic Animals. By Martin Klimmer. 1923. English translation by P. Fischer.

Oilseeds and Oils and Oilcakes :

The following are books or general articles dealing with particular oilseeds and their products:

Linseed. *Bull. Impl. Inst.*, 1911, **9**, 355.

China Wood Oil. *Bull. Impl. Inst.*, 1913, **11**, 441.

Perilla Seed. *Bull. Impl. Inst.*, 1920, **18**, 479.

Hemp Seed. *Bull. Impl. Inst.*, 1912, **10**, 94.

Para Rubber Seed. *Bull. Impl. Inst.*, 1911, **9**, 35; 1913, **11**, 551; 1919, **17**, 543.

Cotton Seed. As cotton seed is a by-product of cotton growing, information on cultivation will be found in Volume III. of the present series and in the various works on cotton growing.

Cotton Seed Products. Lamborne.

Rape Seed. *Bull. Impl. Inst.*, 1915, **13**, 452.

Soya Beans. The Soybean. By C. V. Piper and W. J. Morse. 1923.

Coconuts and Copra:

The Coconut. By E. B. Copeland.

Coconut Cultivation. By H. L. Coghlan and J. W. Hinchley.

A Practical Guide to Coconut Planting. By R. W. Munro and L. C. Brown. 1920.

General article on cultivation of coconut palm and utilization of products, *Bull. Impl. Inst.*, 1912, **10**, 76, 264.

Copra, Coconut Oil and Cake. *Bull. Impl. Inst.*, 1914, **12**, 557.

Palm Kernels and Palm Oil :

Palm Oil and Kernels. By H. C. Bellows and H. Beckwith. 1913.

Le Palmier à Huile. By J. Adam.

De Oliepalm. By Dr. F. W. T. Hunger. Leiden, 1917.

The Cultivation of the Oil Palm. By J. M. Milligan. 1914.

The African Oil Palm Industry. An extensive series of articles in the *Bulletin of the Imperial Institute* dealing with the occurrence, varieties, and utilization of the West African oil palm, the machinery for oil manufacture, and for shelling the nuts.

Bull. Impl. Inst., 1909, **7**, 357; 1913, **11**, 206; 1917, **15**, 57, 271; 1920, **18**, 209; 1921, **19**, 511.

Palm Kernel Cake and Meal :

Bull. Impl. Inst., 1914, **12**, 485, 577; 1915, **13**, 446; 1916, **14**, 280.

Oil Palm in East Indies :

Investigations on Oil Palms made at the General Experimental Station of the A.V.R.O.S. (Medan). Deals exhaustively with the introduction of the oil palm in the Dutch East Indies, varieties, cultivation, pests and diseases, crop records, manufacture of oil, etc.

For short articles based on the above see *Bull. Impl. Inst.*, 1920, **18**, 209; 1922, **20**, 481.

Oil Palm in Malaya :

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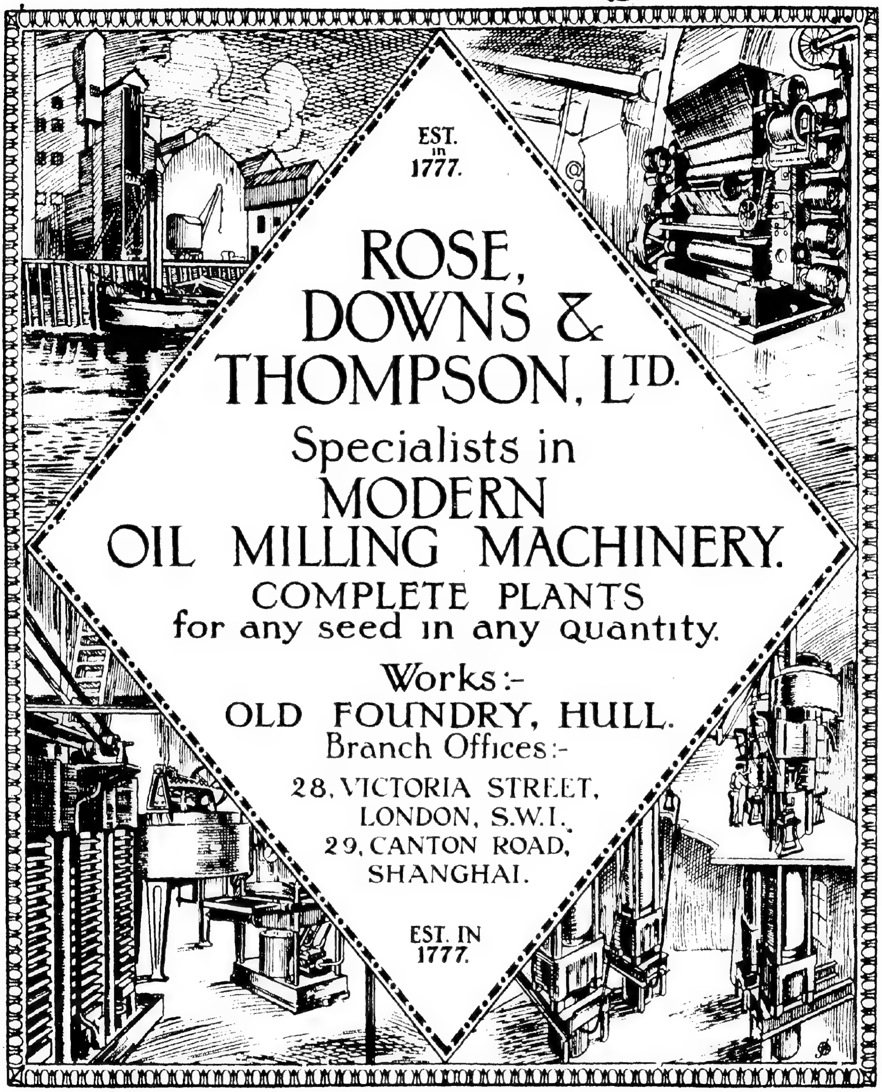

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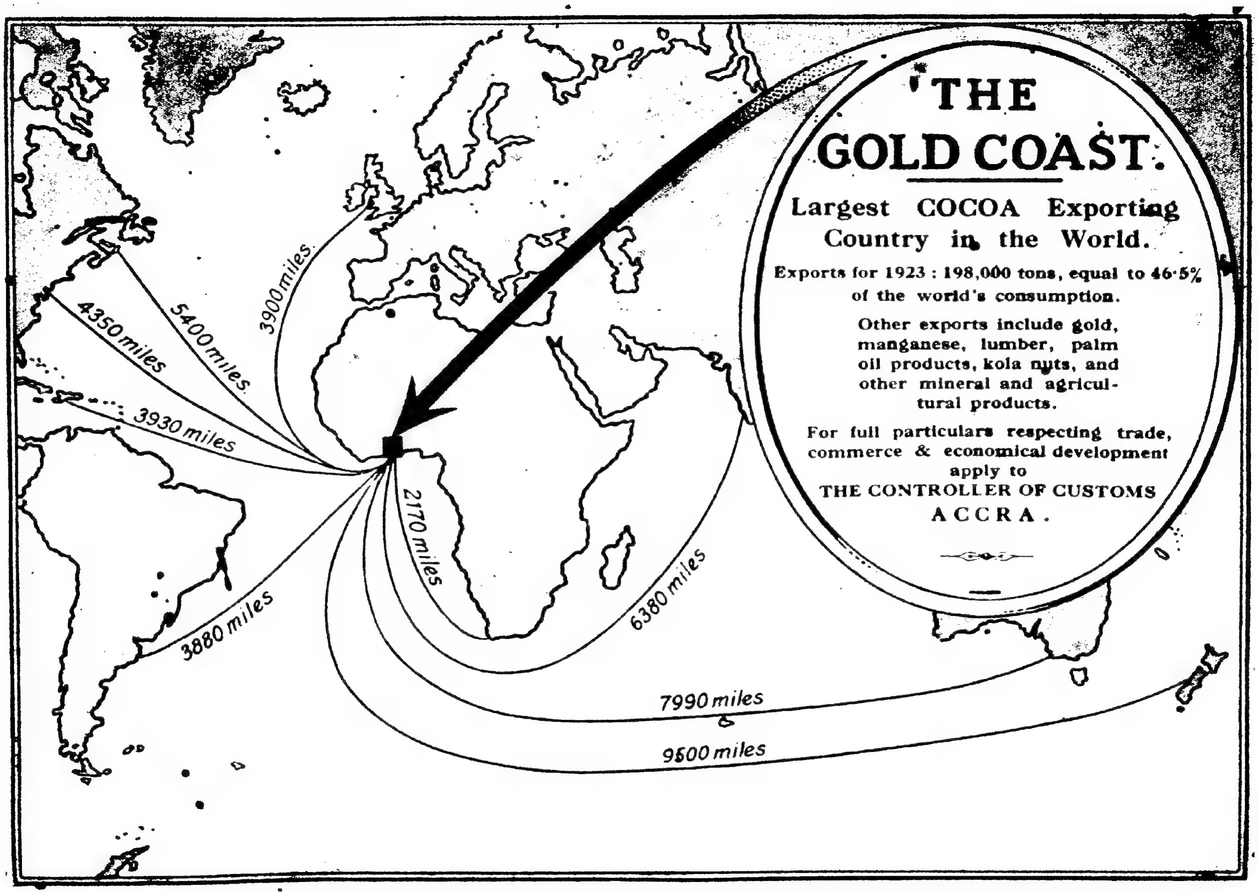
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